Temporary Trade Shocks, Spatial Reallocation, and Persistence in Developing Countries: Evidence from a Natural Experiment in West Africa

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ABSTRACT

In response to rising inequality following decades of trade liberalization, many countries are adopting trade restrictions. Can temporary trade restrictions have long-lasting effects on spatial distribution of employment and resource allocation? To analyze this, we exploit the civil war in Cote d'Ivoire (2002-2007) that disrupted access to world market for two neighboring land-locked countries: Mali and Burkina Faso. The Ivorian war forced rerouting of trade from the Abidjan route to the non-Abidjan routes. We build a general equilibrium model where a subsistence-based autarkic hinterland coexists with an integrated segment, and there are two alternative routes to international market. A trade shock to one route affects resource allocation in both routes by shifting spatial margins of market integration and sectoral specialization. The effects are heterogeneous depending on the pre-war market access of a location. The empirical analysis takes advantage of panel data and estimates the effects on structural change in employment in non-Abidjan route using a triple difference design with location fixed effect. The areas that remain in autarkic equilibrium both before and after the trade shock provide plausible estimates of the changes arising from long-term factors unrelated to the trade shock. The estimates show that the temporary trade shock created divergence between the Abidjan and non-Abidjan routes with accelerated structural change in favor of manufacturing and services employment in the non-Abidjan route. We find evidence of persistence in the effects through higher sunk investment in built-up density, agglomeration through concentration of skilled labor, and more public investment in complementary inputs such as electricity infrastructure (measured by night-lights density).

Key Words: Temporary Trade Restrictions, Regional Development, Structural Change in Employment, Persistence, Path-Dependence, Built-up Density, Skill Agglomeration, Provision of Electricity, Night-Lights

JEL Codes: F15, F16, O24, O55

(1) Introduction

There is a broad consensus among economists that trade liberalization increases productivity and national income, but there has also been a deeper appreciation of the adverse distributional effects in recent years. The inequality associated with globalization and market liberalization exhibits strong spatial pattern in many countries. For example, the coastal areas in China benefited much more than the interior provinces following the opening up and reform initiated in 1978, and the effects of "China trade shock" on USA has been geographically concentrated in certain local labor markets (see, Autor et al. (2016), Kanbur and Venables (2005)).[1] After decades of trade liberalization, many countries are increasingly engaging in trade restrictions partly in response to rising inequality. Can temporary trade restrictions reshape the regional development in a country by changing the spatial distribution of employment and resource allocation? To analyze this, we exploit a natural experiment in West Africa where the civil war in Cote d'Ivoire (CIV) disrupted access to world market for two neighboring land-locked countries: Mali and Burkina Faso.[2]

Abidjan in Cote d'Ivoire was the main seaport handling the bulk of the maritime trade of Mali and Burkina Faso before the civil war broke out in Cote d'Ivoire. The war led to a re-routing of trade from Abidjan to other West African ports such as Dakar, Accra, Lome, and Cotonou. The crisis lasted for 5 years till a political settlement was reached in 2007.[3] We examine whether this temporary negative shock to the Abidjan route led to reallocation of economic activities to the other routes not directly affected by the CIV crisis, and created the preconditions for longer term effects and path-dependent evolution of the regional economy through irreversible investments in built-up density and agglomeration of skilled labor.

In the pre-war period, the road networks in both countries were sparse resulting in high transport costs. As a result, a significant part of the economy was effectively an 'autarkic village economy' with little or no long-distance (international) trade exchanges.

[1] In a series of influential papers, David Autor and his collaborators analyze the effects of China trade shock by focusing on the local labor markets more exposed to Chinese imports in USA.

[2] It is difficult to use the tariff and non-tariff policy restrictions in a country for such an analysis, as the policy choices are endogeneous.

[3] This is a useful time frame, as an elected government has a 4 year tenure in many countries, and temporary trade restrictions imposed by a populist government may be overturned by a new government.

We develop a spatial equilibrium model that allows for the co-existence of an integrated segment characterized by sectoral (agriculture vs. manufacturing) specialization and a subsistence-based autarkic hinterland within the same country. The model includes two trade routes in a country: a route affected by the shock directly, called the "Abidjan route", and a second route for trade through alternative ports, called the "non-Abidjan route".

The focus of our analysis is on spatial heterogeneity and persistence in the effects of the temporary trade cost shock on different routes. We consider spatial heterogeneity at two margins of adjustment along a route: the spatial margin of market integration (henceforth SMI) and the spatial margin of specialization (henceforth SMS). The SMI separates the subsistence-based autarkic region from the integrated segment of the economy characterized by specialization according to comparative advantage driven by inter-regional and international trade. The SMS, on the other hand, separates the zone of manufacturing specialization from that of agricultural specialization within the integrated segment of the economy. To understand whether the reallocation triggered by a temporary trade shock can lead to persistent effects, we analyze irreversible investments in built-up density (housing and manufacturing structures) by taking advantage of the recently available satellite data on global human settlement. In addition, we provide evidence on the role played by reallocation of skilled labor (agglomeration externalities) and public provision of complementary inputs such as electricity (using night-lights density as an indicator).

The theory shows that a trade shock to one route affects resource allocation across routes and also along a given route at different locations differentiated by the initial (pre-war) market access. An important insight is that a temporary trade shock shifts both spatial margins (SMS and SMI) along a given route leading to ambiguous overall effects on employment structure; but it also leads to well-defined heterogenous effects with respect to the initial (pre-war) extent of market access of a location. In particular, the areas with the poorest market access in each route are not affected by the trade shock which plays an important role in our research design.

For the empirical analysis, we combine the satellite data on global human settlement with data from two rounds of population census to create panel data sets at the commune level. To estimate the effects of the CIV trade shock on spatial reallocation across Abidjan and non-Abidjan routes, we adopt a triple-difference strategy with location fixed effects. A difficult challenge in analyzing the effects of a large-scale trade cost shock is that, because of general equilibrium effects, it may be difficult, if not impossible, to find a comparison area that remains unaffected (Donaldson (2015)). This is especially challenging in developed countries where the economy is spatially well-integrated by extensive transport infrastructure. The fact that, in many developing countries, a significant part of the economy is effectively in an isolated autarkic equilibrium offers us a plausible strategy; we can use as comparison the part of the economy that remains autarkic both before and after the trade shock. The changes in employment structure and built-up density observed in these comparison areas cannot be due to the trade shock, and thus provide an estimate of the structural changes due to the underlying long-term technological and institutional factors.

The core of our empirical strategy is to compare the DID estimate of the effect of the CIV crisis on the integrated segment of the non-Abidjan route with the corresponding DID estimate for the integrated segment of the Abidjan route, with the respective autarkic areas as the comparison. It is important to appreciate that the triple-difference set-up is used for understanding the spatial reallocation, not for estimating the causal effects of the negative trade shock on a route. An important advantage of our focus on spatial and sectoral reallocation is that the intractable problem of double-counting one faces while estimating the causal effects is not relevant in our context.[4] Using data on a vector of relevant characteristics, we find that the Abidjan and non-Abidjan routes in both Mali and Burkina Faso do not differ significantly in the pre-war period, thus allaying the worry that the shifts in the spatial margins of integration and specialization would have been substantially different across different routes even in the absence of the trade shock caused by the civil war in Cote d'Ivoire. The panel data allow us to difference out the time-invariant characteristics using fixed effects, thus addressing the concern that differences in natural agricultural endowments may be partly responsible for the differences in sectoral employment shares observed across routes.

The empirical analysis produces three key findings. First, we find that a substantial part of the economy in both the Abidjan and non-Abidjan routes remained essentially

[4]For discussions on the double counting problem, see Redding and Turner (2015) and Donaldson (2015).

in isolated autarkic equilibrium both before and after the CIV trade shock. The trade shock shifted the spatial margin of integration (SMI) outward in the non-Abidjan route, thus expanding the zone of market integration, and had the opposite effects in Abidjan route. Second, the CIV trade cost shock substantially increased the employment share in manufacturing, and trade and services in the integrated areas of non-Abidjan route, suggesting accelerated structural change in the non-Abidjan route when compared to the Abidjan route that bore the direct impact of the civil war in CIV. Third, the effects of the CIV war on regional development (Abidjan vs. non-Abidjan) may be long-lasting; the evidence suggests positive impacts on sunk investment in built-up density, higher growth in night-lights density (capturing greater expansion of electricity grids), and geographic concentration of skilled labor (capturing agglomeration) in the integrated areas in the non-Abidjan route. The persistence in the impacts of CIV-crisis is supported by the trade flow data which confirms that the share of maritime trade flow through Abidjan route never recovered to its pre-crisis level even 10 years after the end of the crisis.

Rest of the paper is organized as follows. We discuss the related literature in section (2) and put the contributions of the paper in context. The next section provides details on the country contexts and the civil war in Cote d'Ivoire. Section (4) develops as a simple general equilibrium model and derives testable predictions about reallocation and employment structure across Abidjan and non-Abidjan routes. Data sources and variables are described in section (5). Section (6) develops the empirical strategy, and section (7) contains the main empirical results. The paper concludes with a summary of the main findings.

(2) Related Literature

There is a substantial and rapidly growing literature on the effects of trade costs on economic activity (for an excellent recent survey see Donaldson (2015)). The recent literature on transport costs emphasizes possible heterogeneity in the impacts of transport interventions. While transport investment is found to have significant positive impacts on many dimensions of economic development (see Donaldson (2018), Donaldson (2015),Emran and Hou (2013), Fafchamps and Shilpi (2005), Berg et al. (2016), and Emran and Shilpi (2012)), there is also evidence where these investments led to negative effects or no changes in outcomes (Faber (2014), Banerjee et al. (2012), Baum-Snow et al. (2017), Asher and Novosad (ming)).[5] We provide a framework that explains the spatially heterogeneous impacts in the context where a significant part of the economy may be subsistence based and not integrated with the world market.

Our analysis is closely related to the influential study of Redding and Sturm (2008) who investigate the effects of Berlin Wall on population growth rate of West German cities located near the border. Interpreting Berlin Wall as a negative shock to market access and hence to trade, they find that cities, particularly the smaller cities, located near the Berlin Wall experienced a substantial decline in population growth relative to the other West German cities. Our study differs from Redding and Strum (2008) in two aspects. The trade/transport shock we consider is a shorter term shock lasting no more than 5 years as opposed to Berlin Wall which lasted over decades. Perhaps more importantly, we not only analyze the effects on structural change in sectoral employment shares, but also provide evidence on three factors that might create path-dependence and longer-term persistence: sunk investment in built-up density, public provision of electricity infrastructure as captured by night-lights density, and skill concentration (agglomeration) as measured by proportion of working population with secondary and higher schooling.

The persistence of the impacts of temporary shock on spatial development has attracted considerable attentions in recent empirical literature on transport infrastructure. In an important paper, Bleakley and Lin (2012) study the cities created by the portage needs at the falls along major rivers in USA and found that population density in former portage sites maintained their historical levels even after portage became obsolete due to technical progress. Jedwab and Moradi (2016) and Jedwab et al. (2017) examine the long term impacts of colonial rail-roads in Ghana and Kenya respectively. They find large positive impacts of rail road on urbanization and distribution of economic activities and the effects had persisted long after the sharp decline of rail-roads during the post independence pe-

[5] Faber (2014) reports evidence of deindustrialization in China. Blankespoor et al. (2018) show that a bridge over Jamuna river in Bangladesh that reduced transport costs by 50 percent led to deindustrialization in the newly connected hinterland, but also led to economic revival by facilitating higher agricultural productivity.

riod. The path dependence in these studies arises from increasing returns to scale in local activities.[6] Our study focuses on the hard footprint of a relatively short-lived transport shock in the context of a predominantly rural/agricultural economy. We find that areas with better initial market access tend to respond in a way that is consistent with creation of preconditions for localized increasing returns in the long run. An advantage of our setting is that it minimizes the possibility of other interventions that may affect the outcomes in the longer term. A small and emerging literature examines the impacts of transport shocks in the context of African countries. In an interesting paper, Storeygard (2016) uses change in fuel price to identify the effects of transport cost on urban growth in the context of African countries.

(3) The Background and the Natural Experiment

(3.1) Trade Routes in West Africa

Burkina Faso and Mali are two landlocked West African countries. Both countries rely on a network of major roads to access ports along the West African coast. The map in Figure 1 describes the main West African trading routes. There are six main routes connecting both countries to seaports on the coast. Burkina Faso can access ports of Abidjan (CIV), Tema and Tekoradi (Ghana), Lome (Togo) and Cotonou (Benin). In addition to these ports, ports in Dakar (Senegal) and Conarky (Guineau) are also accessible to Mali. The highways connecting these countries to sea ports are also the main highways in both countries for internal trade. This means that any disruption to these routes would affect not only the trading costs for exports and imports, but also for inter-regional trade within a country. Though both Mali and Burkina can access several ports along the west African coast line, Abidjan in Cote d'Ivoire (CIV) had been the main port handling their maritime trade. The importance of Abidjan for maritime trades of Mali and Burkina is evident from Figures 2a and 2b which show the volume of trade of these two countries handled by different

[6]There is a broader literature on the persistence in the impacts of population shocks on urban growth. For evidence suggesting a lack of persistence of negative population shocks, see, among others, Davis and Weinstein (2002), Miguel and Roland (2011). For positive population shock due to migration following the demise of apartheid in South Africa, Bakker et al. (2019) find evidence of path dependence at the destinations similar to Schumann (2014).

ports between 1998 and 2006 for Mali and 1998-2016 for Burkina Faso. In 1998, nearly 65 percent of Mali's and 60 percent of Burkina's import and export passed through the port of Abidjan. Cross border trade along this route has also been important as people in areas near borders share similar ethnic and linguistic backgrounds.

Cote d'Ivoire Civil War (2002-2007)

Access to Bamako-Abidjan in Mali and Ouaga-Abidjan in Burkina Faso routes was severely disrupted during Ivorian civil war. The civil war started when the citizen and voting rights issues spurred tension among different ethnic and religious groups during the democratic transition following the death of its first president. The armed conflict flared up in 2002 and continued till 2006 when Ivorian national soccer team qualified for 2006 FIFA World Cup and brought warring parties together to agree on truce for further peace negotiations. A peace treaty was concluded in 2007 ending the armed conflict. As a result of these long running political crises and civil war, the most important trading routes for Mali and Burkina Faso – from Bamako and Ouagadougou to Abidjan – were severely affected. At the height of civil war in 2002-2003, the port of Abidjan was closed for months. In 2002-2003, none of Burkina's import and export passed through Abidjan. Maritime trade for Mali through the port of Abidjan accounted for less than 15 percent of total trade (Figure 2b). Nearly all of the trade through Abidjan in 2003 was diverted to the other West African ports: Tema and Takoradi in Ghana, Lome (Togo) and Dakar (Senegal) (Figures 2a and 2b). From 2007 onward, transit through Abidjan started to recover but even by 2016, it was well below its pre-CIV crisis level for Burkina.[7] While the effect of political instability on maritime trade is evident from Figures 2a and 2b, volumes of trade that took place among neighboring countries are not recorded officially by routes. But the disruption of trade along Abidjan route is expected to have similar adverse effects on the inland trade as well. It is clear from Figures 2a and 2b that shock to trade routes coincided with the CIV political crisis and the impact of shock lasted about 6 years before it started to recover. The shock was thus temporary but not too short-lived as to make no difference. We exploit this negative shock to transit through Bamako-Abidjan and Ouagadougou-Abidjan routes

[7]For Mali, we do not have access to more recent transit data.

as a source of exogenous variation in market access concentrated in a particular region in Mali and Burkina Faso.[8]

(4) Conceptual Framework

We develop a model that incorporates two distinguishing features of a poor developing economy. First, the production structures of poorer developing countries are dominated by agriculture. The share of non-agricultural employment in Mali and Burkina was less than 10 percent in the pre-CIV crisis period.[9] Second, roads are sparse and paved roads are rare. The high costs of transportation means that not all areas trade with each other and pockets of autarkic subsistence economies are more of a rule than exception.

(4.1) The Basic Set-up

Geography and Endowment

We take the location of cities and the transport network as given, and then examine how spatial distribution of population and sectoral employment shares respond to a shock to transport costs. We consider a country which consists of two cities: K and J. City K uses port of Abidjan for its international trade and city J uses an alternative (non-Abidjan) port. There are a continuum of locations around city $K(J)$ along a line with the city center at the one end denoted by $K^0(J^0)$, and the location farthest from the city center denoted as $K^1(J^1)$. Each location along $[K^0, K^1]$ is indexed by i, and its distance from city center K^0 is denoted as d_i. Shipping of a good from K^0 to any location i along the line involves a product specific iceberg cost $e^{\tau_q d_i}$ where $\tau_q > 0$ represents the unit transport cost of product q. Each location i is endowed with $T_i = T > 0$ units of land. There is a mass of N workers in this economy, each supplying 1 unit of labor inelastically. Labor is mobile across all locations. Two cities K and J are identical to each other in terms of all relevant characteristics including access to international markets (though through different

[8] There was a very brief political violence in 2011 in CIV that started in March 2011 and ended on April 11, 2011 with the arrest of Laurent Gbagbo by French forces.

[9] The share of manufacturing employment was less than 5 percent during the pre-CIV crisis period in both countries.

ports) during the pre-crisis period. Taking advantage of the symmetry, we focus on city K to describe the initial equilibrium.

Technology and Comparative Advantage

We consider a four-goods economy; each location can produce three traded goods and a nontraded service. There are two types of manufacturing goods: m denotes modern and z traditional manufacturing goods.[10] The manufacturing goods (m and z) and agriculture (x) are tradable, and housing (h) is non-traded service. Manufacturing and agriculture are produced by combining labor (L) with land (T) whereas housing is produced using land (T) only. The production technologies are constant returns to scale:

$$Q_{xi} = A_{xi} T_{xi}^{\beta} L_{xi}^{1-\beta}; Q_{mi} = A_{mi} T_{mi}^{\beta} L_{mi}^{1-\beta}; Q_{zi} = A_{zi} T_{zi}^{\beta} L_{zi}^{1-\beta}; Q_{h_i} = A_{hi} T_{si}$$

where A_{xi} is the total factor productivity in agriculture, and similarly for the other commodities.

Each sector is characterized by perfect competition at each location. Constant returns to scale, free entry and profit maximization by the firms imply that, in equilibrium, the following marginal conditions hold (let q index manufacturing and agricultural goods, i.e., $q \in [x, m, z]$:

$$A_{qi}(1-\beta) T_{qi}^{\beta} L_{qi}^{-\beta} = \frac{W_i}{P_{qi}} = \frac{(1-\beta) Q_{qi}}{L_{qi}};\ q \in x, m, z \quad (1)$$

$$\beta A_{qi} T_{qi}^{\beta-1} L_{qi}^{1-\beta} = \frac{r_i}{P_{qi}};\ A_{hi} = \frac{r_i}{P_{hi}};\ q \in x, m, z \quad (2)$$

Where P_{qi} is price of $q \in [x, m, z]$, P_{hi} is the price of housing, W_i and r_i are wage and land rental respectively.

For simplicity, we assume that factor productivity in h does not vary across location ($A_{hi} = A_h$). Factor productivity of traded goods (x, m, z) are subject to agglomeration externality. Agglomeration economy in manufacturing arises from learning externality, closer input-output relationship and thick labor market. Similarly, technology adoption in

[10] These are the "z" goods of Hymer and Resnick (1969).

agriculture is observed to spread through social networks. To allow for these agglomeration externalities, we assume that productivity of a traded good q in location i can be expressed as $A_{qi} = \bar{A}_q n_i^{\alpha_q}$ where $\bar{A}_q$ is the intrinsic local productivity which is assumed to vary across products but not across locations, n_i is the population density ($= \frac{N_i}{T}$) and α_q is the agglomeration parameter which is assumed to be smaller than β to ensure an interior solution. We assume that the country has comparative advantage in production of x and z relative to the rest of the world.

Preferences and Consumer Optimization

There is a representative consumer in each location with identical preferences over consumption of four goods and services: agriculture, manufacturing, and housing.

$$U = C_m^{\gamma} C_x^{\delta} C_z^{\eta} C_h^{1-\gamma-\delta-\eta}$$

The utility maximization implies the following demand functions:

$$C_{mi} = \frac{\gamma y_i}{P_{mi}};\ C_{xi} = \frac{\delta y_i}{P_{xi}}; C_{xi} = \frac{\eta y_i}{P_{zi}};\ C_{si} = \frac{(1-\gamma-\delta-\eta)y_i}{P_{hi}}$$

where y_i is the income of the representative consumer in location i. Given the prices of the four products, the indirect utility function for the representative consumer in a location i can be derived as:

$$V_i = \frac{\gamma^{\gamma}\delta^{\delta}\eta^{\eta}(1-\gamma-\delta-\eta)^{1-\gamma-\delta-\eta} y_i}{P_{mi}^{\gamma} P_{xi}^{\delta} P_{zi}^{\eta} P_{hi}^{1-\gamma-\delta-\eta}} \tag{3}$$

(4.2) Equilibrium Before the CIV Crisis

Given the pattern of comparative advantage, city K exports x and z, and imports m. The small country assumption implies that prices of x, m and z at the port of entry (e.g. Abidjan) are given parametrically from the international market. Prices of these goods at the city center K_0 can be expressed as

$$
\begin{aligned}
P_{qk^0} &= \tilde{P}_q(1-\theta_k), q \in x, z \\
P_{mk^0} &= \tilde{P}_m(1+\theta_k)
\end{aligned}
$$

where $\tilde{P}_q$ is the international price at port of entry/exit, and θ_k is the transport cost from port of entry/exit to the city center K^0. Note the asymmetry in the way transport from port to city center affects exportables and importables. It increases price of importables to consumers but reduces the price received by producers of exportables.

Given endowment, preference, and technology, a competitive equilibrium in this economy is characterized by a set of prices (goods and factors) such that (i) the labor market clears locally, regionally and at the country level; (ii) the land market clears at the local level, land being the immobile factor of production; and (iii) utility is equalized across locations as workers are mobile. We assume that transport costs (τ_q) fall in an intermediate range such that each city has areas that do not engage in international trade, which we call the "isolated hinterland". Rest of the areas engage in trade and form an integrated region. Let K^* be the border of the integrated and isolated sub-regions, we call it the spatial margin of market integration (SMI). Around a city K, areas along $[K^0,K^*)$ are in the integrated region and $[K^*, K^1]$ are in the autarky.

Equilibrium in the Isolated sub-region

We start with the characterization of the equilibrium where there is no international trade. Given the absence of heterogeneity in productivity and CRS technology but positive transport costs, the competitive equilibrium is characterized by autarky where each location produces all three tradable goods. The shares of land devoted to agriculture, manufacturing and housing are direct function of their respective income and output shares.[11] The shares of labor employed in modern and traditional manufacturing are equal to $\frac{\gamma}{(\gamma+\delta+\eta)}$ and $\frac{\eta}{(\gamma+\delta+\eta)}$ respectively and in agriculture to $\frac{\delta}{(\gamma+\delta+\eta)}$. The relative prices of tradable goods in autarky equilibrium are $\frac{P^*_m}{P^*_x} = \frac{A_{xk^*}}{A_{mk^*}}$; $\frac{P^*_m}{P^*_z} = \frac{A_{zk^*}}{A_{mk^*}}$. We show in the online

[11]Housing share of land: $T_{hi} = \frac{(1-\gamma-\delta-\eta)T}{1-(\gamma+\delta+\eta)(1-\beta)}$

appendix that population density does not vary across locations in this case as the relative prices are the same for all locations.

Equilibrium in the Integrated Sub-region

As noted above, price of q at city center (K_0) is equal to $\tilde{P}_q(1-\theta_k), q \in x, z$ and $\tilde{P}_m(1+\theta_k)$ for m. To define the trading and specialization patterns, we assume that $\frac{\tilde{P}_z(1-\theta_k)}{\tilde{P}_m(1+\theta_k)} > \frac{P^*_{zk^0}}{P^*_{mk^0}} = \frac{A_{mk^0}}{A_{zk^0}}$ and $\frac{\tilde{P}_x(1-\theta_k)}{\tilde{P}_m(1+\theta_k)} > \frac{P^*_{xk^0}}{P^*_{mk^0}} = \frac{A_{mk^0}}{A_{xk}}$. These assumptions ensure that x and z are exported and m is imported.

To pin down the specialization pattern with respect to distance from K^0, we assume that $P_{zk^0}A_{zk^0} > P_{xk^0}A_{xk^0}$ and τ_z is higher than a threshold defined later in this section. Under these assumptions, three specialization zones can be identified within the integrated sub-region. In the first specialization zone right around the city $[K^0, K^z]$, only z is produced and exported where $K^z > 0$ is determined by using the condition $\frac{P_{zK^z}}{P_{xK^z}} = \frac{P_{zk^0}e^{-\tau_z K^z}}{P_{xk^0}e^{-\tau_x K^z}} = \frac{A_{xK^z}}{A_{zK^z}}$ as

$$K^z = \frac{1}{\tau_z - \tau_x}\left[\bar{a}_z - \bar{a}_x + (\alpha_z - \alpha_x)\ln(n_{k^z}) + p_{zk^0} - p_{xk^0}\right] \tag{4}$$

where $p_{qk^0} = \ln(P_{qk^0})$ and $\bar{a}_q = \ln \bar{A}_q$, $q \in [x, z]$ and $n_k z$ is the population density at location K^z. In the second specialization zone $[K^z, K^s]$, only x is produced where K^s is determined by using the condition $\left(\frac{P_{zk^0}e^{-(\tau_m+\tau_z)K^s}}{P_{mk^0}} = \frac{A_{mk^s}}{A_{zk^s}}\right)$ as

$$K^s = \frac{1}{(\tau_m + \tau_z)}\left[\bar{a}_z - \bar{a}_m + (\alpha_z - \alpha_m)\ln(n_{k^s}) + p_{zk^0} - p_{mk^0}\right]. \tag{5}$$

In the third specialization zone $[K^s, K^*]$, x is produced for export but z is produced only for local consumption. By equating relative price of x and m under trade with autarky price ratios, we determine K^* as

$$K^* = \frac{1}{(\tau_m + \tau_x)}\left[\bar{a}_x - \bar{a}_m + (\alpha_x - \alpha_m)\ln(n_{K^A}) + p_{xK^0} - p_{mK^0}\right]. \tag{6}$$

Equation (5) implies that an increase in τ_z shortens K^s, and define $\hat{\tau}_z$ such that at $\hat{\tau}_z$, $K^s = K^*$. The economy is characterized by a sub-region specialized in z for self consumption, assuming that $\tau_z > \max\{\tau_x, \hat{\tau}_z\}$ implying $K^s < K^*$. For the empirical work, we define spatial margin of integration as $SMI = max\{K^s, K^*\}$. Spatial margin of specialization (SMS) on the other hand is at K^z.

As shown in the online appendix, land and labor allocation across activities vary across specialization zones. Since housing is non-traded and a constant fraction of land is used for housing regardless of specialization zones. The rest is used in the production of z at any location $i \in [K^0, K^z]$, x at $i \in [K^z, K^s]$ and allocated between x and z at $i \in [K^s, K^*]$. Employment shares follow a similar pattern.[12]

Economy-wide Equilibrium and Worker's Indirect Utility

Labor mobility across locations links the integrated and isolated subregions near each city and across two cities. Labor mobility across areas implies equalization of indirect utility, i.e., $V_i = \bar{v}$. Utilizing the first order conditions along with $V_i = \bar{v}$, we show in the online appendix that population density in the integrated sub-region decreases with an increase in distance from K^0, with its slope determined by transport costs and demand parameters. Since the two cities are identical in the pre-war period, the Cobb Douglas utility and production functions imply that a half of total labor endowment is concentrated in each city and its surrounding areas. The aggregate labor market clearing condition determines $\bar{v}$. Note that the symmetry in the initial equilibrium breaks down once there is a trade cost shock to one of the international trade routes.

Built-up Density

The empirical analysis utilizes data on built-up area to explore the impacts of CIV crisis on sunk investments that can lead to persistent effects. We define built-up density in terms of density of residential housing and manufacturing structures.[13] The proportion of built-up area is defined as equal to the density of housing and manufacturing in the $[K^0, K^z]$ zone of integrated subregion. In rest of the areas, it equals to the density of housing defined in turn by population density (n_i). This definition implies that built-up area should be

[12]At $i \in [K^S, K^*]$, proportion of labor used in agriculture is $\frac{(\gamma+\delta)}{(\gamma+\delta+\eta)}$ while rest used in traditional manufacturing (z).

[13]Though agriculture is the most land-intensive activity, it does not involve buildings/structures. Similarly, small-scale manufacturing production for self-consumption usually do not need a building structure separate from the housing for shelter. More specialized large and medium scale manufacturing catering international markets, in contrast, require fixed structures and leads to a higher built-up density.

more concentrated around city center due to higher population density and concentration of manufacturing.

(4.3) The Effects of the Transport Shock to One Port (Abidjan)

We model the CIV-political crisis as an increase in θ_k and no change in θ_j along alternative routes. Though international prices at the port of entry is not influenced by CIV crisis, transport cost from port (Abidjan) to city K (θ_k) increases as a result of the conflict. An increase in θ_k increases price of import (m) to the consumers $\left(\frac{\partial P_{mK0}}{\partial \theta_k} > 0\right)$ but reduces prices of exportables $\left(\frac{\partial P_{qK0}}{\partial \theta_K} < 0\right)$ to the producers. The CIV crisis did not affect transport cost from port of entry (non-Abidjan) to city J, but it is indirectly affected due to labor mobility between cities. Propositions 1-3 summarize the impacts of a higher θ_k.

The Effects of Trade Cost Shock to the Abidjan Route: Testable Predictions

A trade shock due to conflict in CIV (Abidjan) leads to

(1) shrinking of the spatial margins (i.e., SMI and SMS) around city K dependent on Abidjan port, and expansion of the margins around city J that uses ports other than Abidjan. This leads to a contraction of the integrated region around city K and an expansion around city J, but the overall effects on sectoral employment shares in areas around both cities are ambiguous without additional restrictions.

(2) The effects on employment shares are heterogenous with respect to the pre-crisis extent of market access of a location (inversely related to the distance from city K and J).

(2.a) Around both cities, there is no change in employment pattern in areas with very poor market access such that they remain in the isolated autarkic equilibrium both before and after the trade cost shock;

(2.b) An increase in the employment share of agriculture in areas with better pre-shock market access around K but an increase in the manufacturing share in similar areas around J;

(3) A trade shock to city K results in a decrease in the proportion of built-up areas around it, but an increase in built-up density around J, with the increase most concentrated in areas with better pre-shock market access.

Proof: Please see the online appendix.

Intuitions and Discussion

An increase in the transport cost for areas using port of Abidjan has the immediate impact of increasing the relative price of the importable good in a location that was integrated before the war. This reduces the maximized utility of the consumer in that location. This triggers out-migration and changes in nominal wage and housing prices. The new equilibrium prices are determined in a range that fall between pre-shock and immediate post-shock prices, resulting in a reduction in population in the areas around K and an increase in the areas around J.

The result in proposition 1 that a higher transport cost shrinks the extent of integrated region along the route of directly affected city K by shifting the SMI inward towards the city center (K^0) and extends it in areas around J by shifting the SMI outward (away from city center) can be seen from equations (5) and (6). The shift in SMI around J arises from an increase in population density and associated increase in productivity due to in-migration. The inward shift of SMI around K is caused directly by the increase in relative import price and also a decrease in productivity due to out-migration. In areas around directly affected market/city K, the autarkic region expands leading to an increase in manufacturing in areas which are farther away from K^0 and were specialized in agriculture before the trade cost shock; the home based-manufacturing displacing specialized agriculture in this case. It is clear from equation (5), that an increase in transport cost shifts the SMS inward as well leading to a decrease in manufacturing employment in areas closer to K^0. The overall impact on the employment shares for the entire area surround city K is thus ambiguous.

The movement of population and changes in manufacturing share of employment affect the proportion of built-up areas in both the routes; the built-up density increases around J and decreases around K (proposition 3).

The propositions 1-3 are based on the assumption of no population growth. With population growth, proposition 3 would need to be modified. With positive population growth, the proportion of built-up areas may not decrease around K but the increase around J would outpace that around K. For tractability, the model considers only two economic centers (K, J). In the empirical estimation elaborated later, we utilize a measure of market access proposed by Redding and Turner (2015) that takes account of access to all possible markets.

(5) Data

To estimate the impacts of the trade shock caused by the civil war in Cote d'Voire on Mali and Burkina Faso, we utilize population census and satellite data sources. To detect sunk investment, we rely on built-up density from global human settlement data, and the employment data come from population censuses. Agglomeration is measured by concentration of skilled (higher educated) labor, and the changes in provision of electricity is captured by average night-light luminosity.

Population censuses are available for 1996 and 2006 for Burkina Faso and for 1998 and 2008 for Mali. The first period in the population censuses corresponds to the pre-CIV crisis period and the last year right at the end of the war. The census data come with digital maps of communes in Mali, and of 'departments' in Burkina which are administrative units similar to counties in the USA. We use digital maps from censuses to create commune/department level panel data. The panel data set based on the population censuses includes 371 department in Burkina and 629 communes in Mali, giving us a relatively rich sample of 1,000 sub-districts for our empirical analysis.[14]

The source of built-up and population density data is the Global Human Settlement Layer (GHSL) data set made available by European Joint Research Centre (Pesaresi et al. 2015) and Columbia University, Center for International Earth Science Information Network - CIESIN (2015). With spatially consistent information from four Landsat image collections, these data are available for 1975, 1990, 2000 and 2014. The built-up data are 250 meter by 250 meters, whereas we use 1 km squares for the population grids. We superimpose the digital maps from the censuses on the pixel-level data to estimate the percentage

[14]Total number of departments/communes in Burkina Faso is 374 and Mali 695. Some of the sub-districts lack data on building density and are dropped from the analysis presented here. When we repeat the analysis of employment shares without dropping those extra sub-districts and all results reported here are robust to the inclusion of those sub-districts. Using high resolution data that became available since the data construction of the Burkina Faso department boundaries, we slightly modified the urban boundaries to align with the expected location of urban areas using ancillary and satellite imagery keeping the same shape and resolution of the original data.

of built-up area and population density at the commune/department levels. The GHSL data on built-up density have at least two periods before the war which allow us to check the pre-war trends for both population density and built-up density.

The data on the luminosity of night-lights are drawn from global satellite database. The night-light data are available from 1992 to 2013.[15] We focus on 1992-2011 and exclude the last two years from the sample as data for some of sub-districts are missing in those two years. We use the census borders to construct a panel at commune/department levels. Our focus is on the average night-light luminosity per sq km. An important advantage of the night-light data is that it is available before, during and after CIV civil war. To guard against possible serial correlation, we follow the suggestion of Bertrand et al. (2004) and take average over the relevant years. The pre-war years are divided into two sub-periods (1992-1996 and 1997-2001) and the war years correspond to 2002-2007 and post war years 2008-2011.

The digital maps of the communes/departments and road network are used to compute the distances from each commune center to all six trade routes identified in Figure 1. The distance of a location is estimated as the 'arc distance' from the commune center to the nearest point on the road along a route. Each commune/department is then assigned to the route which is closest to it. Using this shortest distance, we compute distances from the centroid of each commune to all West African cities with population of 35 thousand or more in 1996 from the consolidated urban database by Blankespoor, Khan and Selod (2017), which draws upon population data from Brinkhoff (2018).[16] These arc distances are combined with city population to define a measure of market access which is elaborated in the empirical estimation section below.

[15]The night-light data are collected from a series of DMSP-OLS satellites during the period 1992-2013. In order to enable temporal analysis, we correct for the lack of in-flight calibration using the method in Wu et al. (2013) to adjust for the differences between sensors, acquisition times, and saturation. A newer satellite VIIRS started in 2013. The data from the earlier satellite (DMSP) may not be comparable to that from the new satellite.

[16]West Africa countries include: Benin, Burkina Faso, Cote d'Ivoire, Ghana, Mali, Niger, Togo, Mauritania, Senegal and Guinea Bissau.

(6) Empirical Issues and Strategy

(6.1) The Empirical Models

Employment Pattern: A Triple-Difference Strategy with Location Fixed Effect

To investigate how the trade disruption caused by the civil war in Cote d'Ivoire may have affected the resource allocation across the Abidjan and non-Abidjan areas in Mali and Burkina Faso, we adopt an empirical model that takes advantage of the panel data by combining sub-district level fixed effect with a triple-difference set-up. With a two-period panel of employment shares, the regression specification is as follows:

$$Y_{ija} - Y_{ijb} = \beta_0 + \beta_1 D_T + \beta_2 D_{NA} + \beta_3 (D_T \times D_{NA}) + \gamma Z_{ijt} + \varepsilon_{ijt} \qquad (7)$$

where Y_{ija} is the outcome variable j in commune i after the shock, and Y_{ijb} for the period before the shock. D_T is a dummy variable that takes on the value of 1 if a location is in the integrated segment of the economy and thus is affected by the trade cost shock and zero otherwise, and D_{NA} is a dummy variable that takes on the value of 1 when a location is in the non-Abidjan route and zero otherwise. This definition of D_{NA} allows us to focus better on the reallocation of population and economic activities away from the adversely affected Abidjan route to the non-Abidjan routes. The coefficient β_3 is the focus of our analysis. Denoting an estimated parameter with a hat, $\hat{\beta}_3$ provides us the effect of the trade shock on the non-Abidjan routes relative to the Abidjan route, taking into account both the long-term changes unrelated to the CIV shock and the reallocation across routes driven by mobile factors such as labor. Since the data on skilled labor also come from the censuses, the analysis of spatial concentration of skilled labor also relies on the triple-difference empirical model above.

Built-up and Night-Lights Density: A Quadruple-Difference Strategy with Location Fixed Effect

We have richer time series data on built-up density and night-lights density which allows us to compare the first-differences, thus adding another difference to the triple-difference empirical model set-up for the employment analysis above. The empirical model becomes one of a quadruple difference with location fixed effect. The estimating equation can be written as below:

$$\begin{aligned}\triangle Y_{ijt} = \pi_0 + \pi_1 D_T + \pi_2 D_{NA} + \pi_3 D_{yr} + \pi_4 \left(D_T \times D_{NA}\right) + \pi_5 \left(D_T \times D_{yr}\right) \\ + \pi_6 \left(D_{NA} \times D_{yr}\right) + \pi_7 \left(D_T \times D_{NA} \times D_{yr}\right) + \gamma Z_{ijt} + \varepsilon_{ijt}\end{aligned} \tag{8}$$

where $\triangle Y_{ijt} = Y_{ijt} - Y_{ij(t-1)}$, and D_{yr} is a time dummy defined appropriately for the post-war observation(s) given an outcome variable. For example, for built-up density as the outcome variable, we use a yearly panel consisting of the following years: 1990, 2000, 2014. In this case, we define a dummy D_{2014} that takes on the value of 1 for $\triangle Y_{ij2014} = Y_{ij2014} - Y_{ij2000}$ and zero for $\triangle Y_{ij2000} = Y_{ij2000} - Y_{ij1990}$.[17] The focus of the analysis is on the coefficient of the triple interaction term, i.e., π_7. For night-lights, we can separate out the effects of the war years from that of the post-war years; the specification includes a dummy for war years [2002-2007] and another dummy for post-war years [2008-2011]. The omitted category is the pre-war years in this case. The error term ε_{ijt} could be spatially correlated. To correct for possible spatial correlations, we cluster standard errors at the route level.

The outcome variable Y_{ijt} is expressed in shares for employment, built-up density, and skilled labor, and in logarithms for night-light luminosity. The dependent variables are differenced to wipe out the effects of time-invariant location heterogeneity. This is especially important in our analysis; for example, the labor-share in agriculture in a commune would be determined in part by the land quality and agro-ecological conditions. Part of the differences in employment shares observed between the Abidjan and non-Abidjan routes may be driven by these differences in agricultural endowment rather than the trade cost shock

[17] We have data on 1975 which is used for initial conditions including the 1975 population density as a measure of agglomeration.

to the Abidjan route. For built-up density and skilled labor, the initial level of agglomeration economies may play a role in addition to the sunk investments in creating significant differences between the Abidjan and non-Abidjan routes. To address this concern, we include population density in 1975 as a measure of initial agglomeration economies in a commune/department. The DID regressions condition on a vector of pre-war locational attributes Z_{ij0} which includes log of arc distance to the nearest route, a dummy indicating if the communes are from Mali, in addition to log of population density in 1975. [18]

(6.2) Defining Market Access

Many studies rely on the distance to the nearest city/town as a measure of market access. It seems intuitive in the context of the simple theoretical model developed above where distance to the nearest city (K or J) is a sufficient statistic for market access of a location. However, for our empirical analysis this is likely to be too simplistic as each location has access to a number of city/town markets of different size. It is also important to recognize that all of the areas located at a given arc distance from a city do not have the same market access. For instance, an area located close to an intersection of multiple trading routes tends to have a much better access than an area located on a major route but far from the intersection. This distinction is more consequential in countries such as Mali and Burkina Faso which are predominantly agricultural and trade routes run through areas which are rural and isolated from the urban areas.

Instead of defining a band around a route, we compute a measure of market access suggested by Redding and Turner (2015). The market access variable is computed as:

$$m_i = \ln\left(\sum_h \frac{N_h}{d_{ih}^2}\right)$$

where d_{ih} is the distance of commune i to city h and N_h is the total population of city h. The market access as defined above is the gravity measure widely used in the trade literature; it is equal to the weighted sum of the extent of the urban markets proxied by

[18]The DID results do not change in any significant way if we exclude arc distance to the nearest route from the regressions.

their population. The weight is defined by the reciprocal of distance squared. By definition, markets farther away are given lower weights.

(6.3) Heterogeneity w.r.t Pre-war Market Access and Determining the Autarkic Comparison Areas

A substantial and mature literature shows that economic density in a location is correlated with the access to market[19], and the theoretical analysis above suggests that trade/transport shocks can have differential impacts depending on the extent of market access of a commune/department during the pre-war period. Perhaps, most important for our empirical analysis is the identification of the autarkic comparison areas through a sequential search process noted earlier. To conduct this analysis over the distribution of market access m_i, we divide it into 10 deciles. We then define a dummy for better market access (d_m^σ) as:

$$\begin{aligned} d_m^\sigma &= 1 \text{ if } \sigma > n, n = 2, ...9, \sigma = 3...10 \\ &= 0 \text{ otherwise} \end{aligned}$$

Incorporating the market access heterogeneity, the estimating equation for employment shares can be written as:

$$Y_{ija} - Y_{ijb} = \theta_0^\sigma + \theta_1^\sigma D_{NA} + \theta_2^\sigma d_m^\sigma + \theta_3^\sigma \left(d_m^\sigma \times D_{NA}\right) + \gamma^\sigma Z_{ijt} + \varepsilon_{ijt}^\sigma \tag{9}$$

The focus is on the estimate of θ_3^σ for various values of σ. An important insight from proposition (1) is that the main effect of trade shock would be felt in the areas that are integrated with the world market. We estimate the regressions for progressively higher value of σ and check the statistical significance of the relevant coefficient to identify the areas that remain isolated both before and after the trade shock due to the CIV crisis.

[19] For excellent recent surveys, please see Donaldson (2015), Redding and Turner (2015), Duranton and Venables (2018).

(7) Empirical Results

(7.1) Characterizing the Pre-Crisis Equilibrium

We use data from the pre-crisis period to portray the pattern of population and built-up densities and the employment structure in our study countries. We check for differences in the employment structure between the Abidjan and non-Abidjan areas during the pre-war period using census data. Panel A of Table 1 provides the estimates for sectoral employment shares for the pre-war year available in the data set (1996 for Burkina Faso and 1998 for Mali). The estimated coefficients are not different from zero numerically or statistically. The pre-war period is thus characterized by a spatial equilibrium where the non-Abidjan and Abidjan areas display no significant differences in either employment structure. Evidence is similar for population (in levels); please see Panel B of Table 1. With richer time series data in the pre-war period, the evidence on built-up density and night-lights density in panel B of Table 1 suggest that these two routes did not differ significantly in terms of the trends of these variables in the pre-war equilibrium.

Figures 3a–3d depict the non-parametric plots of population, the proportion of built-up area, and shares of agriculture and manufacturing in total employment against the gravity measure of market access described in section 6.2 above. The relation between the share of manufacturing employment and the measure of market access is convex, with a relatively higher manufacturing share in areas with very low market access which declines initially with an increase in market access and than increases sharply for areas with a market access measure greater than 6. Employment share of agriculture displays the opposite pattern. The relatively higher share of manufacturing in the areas with very poor market access reflects the absence of inter-regional and international trade and their reliance on local (home-based) manufacturing. The patterns of manufacturing and agricultural employment with respect to market access thus confirm that in the pre-war period a sub-region remained isolated from the urban markets due to poor market access. Both population and built-up densities decline with a decrease in market access, consistent with the theoretical analysis. The built-up density, however, tracks more closely the employment pattern in manufacturing than population density for areas with market access greater than 6, suggesting predominance of manufacturing structures in these areas. For the areas with poor market access (≤ 6), the proportion of built-up area is low and the curve is flat. This evidence lends support to the definition of proportion of built-up area based on land used in housing in the isolated region, and in housing plus manufacturing in the integrated region.

The pattern of employment points to a critical value of market access variable of around 4.5 which can be interpreted as an estimate of the spatial margin of market integration (SMI) in the pre-war period. Figure 4 shows the distribution of the communes/departments by market access. The market access measure for about 60 percent of the communes falls below the critical value 4.5. These are the communes/departments that did not engage in long-distance trade and relied on local production for consumption during pre-crisis period.

(7.2) The Effects of Trade Cost Shock on the Employment Pattern

We utilize two rounds of census data to explore the impacts of trade/transport shock on the employment structure along the Abidjan and non-Abidjan routes. In addition to employment in manufacturing and agriculture, we also consider employment in trade and other services. During the pre-crisis period, 91 percent of workers were engaged in agriculture in the study countries. Among those employed in non-agriculture, most were traders (5 percent), followed by manufacturing (2 percent) and rest in services (2 percent). The second round of census data corresponds to 2006 for Burkina Faso and to 2008 for Mali, both years are at around the time of the truce and conclusion of peace treaty in Cote d'Ivoire in 2007. The estimates for employment shares should thus be considered conservative as they relate to the immediate post-crisis years.

(7.2.1) Identifying the Comparison Autarkic Hinterland

An important insight from proposition ($2.a$) is that the areas with very poor market access are essentially isolated hinterland, and their employment structure is not likely to be significantly affected by the trade shock. The empirical analysis in section (7.1) above provides suggestive evidence that, during the pre-CIV crisis period, the isolated hinterland consists of the areas in the lower 60 percent of the market access distribution, i.e., $\sigma \leq 0.60$. Thus the average effects over a route is a weighted average of the zero effect in the autarkic hinterland and the effect of the trade shock on the integrated areas. Since the theory suggest that the trade shock to the Abidjan route will shift the SMI outward in the alternate non-Abidjan routes, we expect the extent of the isolated region to shrink after the shock. If an area remains isolated after the shock, the employment structure will not be affected by the CIV trade shock, and any changes would reflect only the long-term factors in the economy. This provides us with an estimate of the changes in the employment shares due to the underlying trend in the economy and we need to take into account of this trend when considering the effects of the CIV trade shock on employment share in the areas with better market access.

To identify the autarkic areas unaffected by the CIV shock, we define a series of dummies representing better market access d_m^σ for $\sigma = 0.30, 0.40, ...0.80$, following the procedure discussed in section (6.3) above. For example, when $\sigma = 0.30$, the dummy d_m^σ takes on the value of 1 for the areas with a market access measure higher than 0.30. We progressively estimate equation (9) above for higher values of σ and test the null hypothesis at each σ that the coefficient of better market access dummy d_m^σ is not significantly different across Abidjan and non-Abidjan routes, i.e., $H_0(\sigma) : \hat{\theta}_3^\sigma = 0$ in estimating equation (9) above. It is important to appreciate that with a high enough value of σ used to define the better market access dummy, the subset with $d_m^\sigma = 1$ consists only of the areas integrated with the rest of the international market, and the null hypothesis will thus be rejected according to the theory discussed above. We thus search for the lowest value of σ at which the interaction term $(d_m^\sigma \times D_T)$in estimating equation (9) above is statistically significant, thus rejecting the null hypothesis, and identify this turning point as the spatial margin of integration (SMI) after the trade shock.

The estimates from this exercise are presented in Figure 5a-5c. Figure 5a shows the estimates for the share of agriculture in total employment along with the 90 percent confidence interval; the evidence shows that $H_0(\sigma) : \hat{\theta}_3^\sigma = 0$ cannot be rejected at the 5 percent level for $\sigma \leq 0.60$. However, there is significant variation: we see a clear change in the slope of the curve at $\sigma = 0.50$ suggesting a much stronger negative effect which is statistically significant at the 10 percent level at $\sigma = 0.60$.[20] This suggests that the spatial margin of integration (SMI) has shifted outward along the non-Abidjan routes as a result of the CIV trade shock, consistent with the theoretical insights in proposition (2.a). The evidence in Figure 5a thus suggests that the areas that belong to the lower 50 percentile of the market access distribution in the pre-war period did not experience any significant change in the agricultural employment share as a result of the CIV trade shock. The corresponding estimates for the share of manufacturing employment in Figure 5.b show a similar spatial pattern; the null hypothesis of no difference between Abidjan and non-Abidjan routes (i.e, zero effect of the trade shock) cannot be rejected at the 5 percent level for $\sigma \leq 0.60$, but, again, there is a sharp change in the magnitude of the effect from $\sigma = 0.50$ to $\sigma = 0.60$,and the null hypothesis can be rejected at the 10 percent level when $\sigma = 0.60$. Figure 5.c provides similar evidence for trade and other services. The evidence in Figures 5a-5c thus suggests that the spatial margin of integration (SMI) in the post-war period falls in the interval between $\sigma = 0.50$ and $\sigma = 0.60$.

(7.2.2) The Effects of the Trade Shock on the Employment Pattern in the Integrated Areas

Motivated by the evidence that the SMI in the post-war period belongs in the interval $\sigma \in (0.50, 0.60)$, the central case we consider is based on a cut-off of $\sigma = 0.55$. Thus the central-case estimates focus on the average effect on the whole integrated sub-economy in Abidjan vs. non-Abidjan routes. This implies that the "treatment dummy" in equation (7) is defined as $D_T = 1$ if a location falls in the upper 45 percentiles of market access distribution, and zero otherwise. For notational clarity we write the "treatment" dummy as $D_T^{0.45}$ for the central case. Later we consider possible heterogeneity in the effects of CIV shock within the integrated segment, by defining $D_T^{0.40} = 1$ when a location falls in the upper 40 percentiles of market access (pre-war) distribution. We also analogously define another treatment dummy $D_T^{0.30}$.

[20] Recall that in section (7.1) the evidence suggests that the SMI is located at around the 60th percentile of the market access distribution in the pre-war period.

The Average Effects for the Integrated Region in a Route

We begin the discussion with the estimates for the central case, i.e., with $D_T^{0.45}$ as the treatment dummy; please see panel A of Table 2. For agriculture (column 1 of Table 2), the estimated intercept implies a reduction of its employment share by 10.3 percentage points in the Abidjan hinterland because of the underlying long-term factors, and the corresponding estimate for the non-Abidjan hinterland is a reduction of 5.3 percentage points. Proposition (2.b) predicts the trade shock to increase the proportion of agricultural employment in the integrated areas along the Abidjan route (directly affected by the CIV war); the estimate shows a 4.5 percent increase in the share of agricultural employment compared to the autarkic hinterland. In sharp contrast, along the non-Abidjan route, the integrated ares experienced a negative impact (-4.7 percentage points) on the share of agricultural employment. Thus, the trade shock accelerated the decline of the share of agricultural employment in the integrated areas in non-Abidjan route relative to that in the Abidjan route.

The estimates effects on the share of manufacturing employment reported in column 2 of Table 2. The estimates in panel A shows that the effects of the trade shock on manufacturing employment was very different compared to the effects on agriculture discussed above. The intercept estimate suggests that the share of manufacturing employment increased by 6.3 percentage points in the autarkic hinterland due to structural change unrelated to the trade shock. The trade shock resulted in a slower structural change in favor of manufacturing in the integrated segment of the Abidjan route; the share of manufacturing employment increased by only 2.5 percentage points. The evidence for the non-Abidjan route in contrast shows that the pace of structural change in favor of manufacturing accelerated in the integrated segment due to the CIV trade shock by 3.6 percentage points relative to the Abidjan route. The estimates for employment in trade and other services in column 3 of Table 2 show a pattern similar to that found for the manufacturing employment. The CIV trade shock resulted in a lower growth in the employment share of trade and services in the integrated segment of the Abidjan route, but led to opposite effect in the integrated segment of the non-Abidjan route. This reallocation across routes (through labor mobility) and locations along a route (through shifts in the spatial margins SMI and SMS) and the resulting difference in the regional development is the focus of the paper.[21]

Heterogeneity within the Integrated Region

To check if the effects of trade shock vary across locations within the integrated segment, we report estimates of the effects for treatment areas defined for progressively better pre-war market access. The estimates corresponding to the $D_T^{0.40}$ are reported in panel B of Table 2, and those for $D_T^{0.30}$ are in panel C of Table 2. A comparison of the estimates in panel B and panel C with those in panel A shows the pattern of the effects remain same for changes in the employment share of agriculture, manufacturing, and trade and services. However, the numerical magnitudes vary by the pre-war market access; the effects of the CIV trade shock on the structural change on the integrated segment of the non-Abidjan route are stronger for a location with better pre-war market access. The decline in the share of agricultural employment in the integrated non-Abidjan areas was on average 5.7 percentage points when the treatment locations consist of locations with pre-war market access in the upper 40 percentile of the distribution (i.e., for the treatment dummy $D_T^{0.40}$) , and the effect increases to 6.3 percentage points for the areas in the upper 30 percentiles of the pre-war market access distribution (i.e., for $D_T^{0.30}$). This implies a 21 percent higher impact for $D_T^{0.40}$, and a 34 percent higher impact for $D_T^{0.30}$ compared to the average impact over the whole integrated segment reported in panel A of Table 2. The estimates for the employment shares of manufacturing, and trade and services also show a monotonically increasing effect of the CIV trade shock with better pre-war market access within the integrated zone, but the numerical magnitudes are much smaller.

(7.3) Long-term Effects of Temporary Trade Shock

The evidence discussed above in section (7.2) suggests that the temporary trade shock caused by the CIV civil war led to significant changes in the employment pattern in the non-Abidjan route when compared to the directly affected Abidjan route. In this section, we

[21] We emphasize here that the differential effects estimated for the non-Abidjan routes capture the reallocation effect, not the causal effects of the trade shock on a given route because of "displacement" and double counting when comparing the Abidjan and non-Abidjan areas.

analyze whether there are reasons to expect that the changes observed in the employment pattern may be longer-lasting, and may not revert back to the pre-war pattern of resource allocation and sectoral specialization. If the empirical estimates are capturing only the reallocation of mobile factors without any sunk investments, then one would expect the share of Abidjan route in total trade to revert back close to its original level after the end of the CIV-crisis. Empirical evidence in this regard is quite the contrary. For Burkina Faso, we have trade flow data till 2016 which is plotted in Figure 2a. The analysis of trade flow confirms that the share of maritime trade flow through Abidjan route never recovered to its pre-war level even 10 years after the end of the CIV crisis. This alerts us to the possibility of differential levels of sunk investments in Abidjan and non-Abidjan routes. If the CIV war led to under-investment public goods in the Abidjan route, one would expect that firms and people would find it costly to relocate back to the Abidjan areas after the end of the war in 2007. The sunk investments can create "quasi rents" a la Milgrom and Roberts (1992), and slow down the process of the readjustment and reversion back to the original equilibrium. We consider two potential sources of such sunk investments: built-up density and public non-transport infrastructure provision such as electricity. As the trading and general economic activity suffered in the Abidjan route because of the CIV civil war, it is likely that government reallocated public investment from the Abidjan areas to the non-Abidjan areas. We analyze the effects of the CIV shock on night-lights density as an indicator of public investment in electricity.

Evidence on Built-up Density

It is difficult to find data on indicators of sunk investments, but the recently available global settlement data provide an excellent source especially in the context of developing countries. We take advantage of the global settlement data to explore the effects of the CIV shock on built-up density as a measure of sunk investment. The estimates of the effects of the CIV shock on the proportion of area built-up density are reported in Table 3. The effect of the CIV shock on the integrated areas of the non-Abidjan route in this case is estimated as a quadruple difference, please see the coefficient of the $(D_T^{0.45} \times D_{NA} \times D_{2014})$ in row 1 of Table 3. Column 1, row 1 of Table 3 gives us the average effect on built-up density over the whole integrated segment along the non-Abidjan route; the estimate suggests that the proportion of area built-up experienced a 2.6 percentage points increase as a result of the CIV shock compared to that in the integrated segment of the Abidjan route. This supports the idea that the CIV shock created preconditions for longer-term effects on the employment structure and the effects are likely to be persistent.

The estimates for possible heterogeneity within the integrated segment shows that the point estimates increase monotonically, but the numerical magnitudes are not substantial (see column 2, row 1 for the estimate for $D_T^{0.40}$, and column 3, row 1 for $D_T^{0.30}$).

Evidence on Night-lights Density

As noted earlier, an important channel through which the CIV civil war might have led to persistent regional effects in Mali and Burkina Faso is reallocation of non-transport infrastructure investments by the government. A salient example of such public investment in a developing country is the electricity generation and distribution network. Since electricity is a general input used by most of the economic activity, it provides us a good measure of complementary public inputs valued by the private entrepreneurs. In addition, electricity is also important as amenity by providing lighting in residential housing. We thus use night-light density as a measure of changes in electricity provision by the government in response to the CIV crisis. The results for the effects of trade shock on the night-light density are reported in Table 4.

With richer time series of data, the analysis of night-lights can differentiate the effects during the war period (2002-2007) from the post-war impact. The estimates for the war period are reported in row 1 of Table 4; the column 1 shows that the average effect is positive in the integrated areas of the non-Abidjan route as a whole. The estimate suggests that, in comparison to the integrated areas in the Abidjan route, the non-Abidjan integrated areas had a 36 percent higher growth in night-lights density during the war period. The estimate in the second row for the top 40 percentiles of market access indicates a 27 percent higher growth in the night-lights density in the integrated areas of non-Abidjan route on average. The night-light density results thus point to possible path dependence in economic density in the sense that temporary shock in trade cost led to changes in economic density that did not revert back to the pre-shock equilibrium.

The estimates for possible heterogeneity within the integrated segment (for $D_T^{0.40}$ and $D_T^{0.30}$) show that the effect of CIV shock declines substantially for the areas with the highest pre-war market access. This is consistent with the observation that changes in night-lights density may be very low in areas with almost universal electricity access and high income to begin with in the pre-war period.

Evidence on Skilled Labor

The role played by agglomeration externalities generated by concentration of high-skilled population is a central mechanism that creates long-term persistence and path-dependence. In section 7.3.2 above, we discuss evidence suggesting that the CIV crisis led to reallocation in favor of manufacturing employment in the integrated areas of non-Abidjan route. Since manufacturing activities are more likely to generate agglomeration externalities, we would expect reallocation of skilled labor to play a role. Table 5 reports the estimated effects of the CIV trade shock on the proportion of working population with secondary or more schooling. The evidence in all three columns suggests that the trade shock increased the concentration of skilled labor in the integrated areas of non-Abidjan route. The estimate in column 1, row 1 of Table 5 implies a 1.6 percentage points higher share of skilled labor on average in the integrated areas of non-Abidjan route as a whole.

(7.4) Effects on Population Density

A central mechanism through which the reallocation of economic activity occurs across routes is movement of people from the adversely affected areas. To provide some evidence on the role played by mobility of people, we look at the effects of the CIV crisis on population growth. The estimates are reported in Table 6. The point estimates for the effects are positive in all three columns corresponding to $D_T^{0.45}$, $D_T^{0.40}$, and $D_T^{0.30}$, but the estimates in the first two columns are not precise. The estimate in the third column shows that the areas with pre-war market access in the upper 30 percentiles of the distribution experienced a 5.7 percent higher growth rate in population density if they are located in the non-Abidjan route, confirming reallocation of population from the Abidjan route which was directly affected by the CIV civil war.

(8) Conclusions

We exploit the disruption of trade through the Abidjan seaport due to the civil war in Cote d'Ivoire (2002-2007) as a natural experiment to understand the effects of a temporary trade shock on structural change in employment in the neighboring land-locked countries: Mali and Burkina Faso. The civil war in Cote d'Ivoire cut-off the trade route through the Abidjan port and rerouted the trade through alternative routes (called non-Abidjan routes). The focus of our analysis on how the negative trade shock to the Abidjan route resulted in a divergence in the employment pattern between the areas in Abidjan and non-Abidjan routes, and created preconditions for long-term persistence and path dependence through sunk investments in built-up density and agglomeration by reallocation of skilled labor force.

We develop a simple general equilibrium model that allows for coexistence of an isolated autarkic segment with an integrated segment where resource allocation is determined by comparative advantage and transport costs from the seaport. The theory suggests that, along each route, the segment with poor pre-war market access remains unaffected by the CIV trade shock, as this segment is in isolated autarkic equilibrium both before and after the trade shock. The change in employment structure in this isolated segment are driven solely by technological and institutional factors. We take into account the effects of these long-term factors unrelated to the CIV trade shock by using the isolated segment as the comparison area in a triple-difference empirical design (the other two differences are: before and after the war, and Abidjan vs. non-Abidjan routes). The empirical analysis confirms the existence of an unaffected segment; the areas with pre-war market access in the lower 55 percentile of the distribution remained in the autarkic equilibrium after the CIV trade shock.

The evidence from the empirical analysis suggests that the CIV trade shock resulted in divergence between the Abidjan and non-Abidjan routes; the areas in the integrated segment of the non-Abidjan routes experienced gain in the share of manufacturing and trading employment, while the decline in the agriculture was sharper. The CIV trade shock thus accelerated the structural change in employment in the integrated areas of the non-Abidjan route. The evidence also indicates that the trade shock increased sunk investment in built-up density, and led to higher night-light density and a reallocation of skilled labor to the integrated areas of non-Abidjan route, thus creating a set of preconditions for persistence in the reallocation effects of the CIV shock. The analysis thus suggests that temporary trade shocks can affect regional development in a country in a significant way and the effects are likely to be long-lasting.

Bibliography

Asher, S. and Novosad, P. (Forthcoming). Rural roads and local economic development. *American Economic Review*.

Autor, D., Dorn, D., and Hanson, G. (2016). The china shock: Learning from labor market adjustment to large changes in trade. *NBER Working Paper Series*.

Bakker, J. D., Parsons, C. R., and Rauch, F. G. (2019). Migration and urbanization in post-apartheid south africa. In *Policy Research Working Paper 8764*. World Bank.

Banerjee, A., Duflo, E., and Qian, N. (2012). On the road: Access to transportation infrastructure and economic growth in china. In *NBER Working Paper*. National Bureau of Economic Research.

Baum-Snow, N., Brandt, L., Henderson, J. V., Turner, M. A., and Zhang, Q. (2017). Roads, railroads, and decentralization of chinese cities. *The Review of Economics and Statistics*, 99(3):435–448.

Berg, C. N., Deichmann, U., Liu, Y., and Selod, H. (2016). Transport policies and development. *The Journal of Development Studies*, 53(4):465–480.

Bertrand, M., Duflo, E., and Mullainathan, S. (2004). How much should we trust differences-in-differences estimates? *The Quarterly Journal of Economics*, 119(1):249–275.

Blankespoor, B., Emran, M. S., Shilpi, F., and Xu, L. (2018). Bridge to bigpush or backwash? market integration, reallocation, and productivity effects of jamuna bridge in bangladesh. In *World Bank Policy Research Working Paper 8508*. World Bank.

Bleakley, H. and Lin, J. (2012). Portage and path dependence. *The Quarterly Journal of Economics*, 127(2):587–644.

Davis, D. R. and Weinstein, D. E. (2002). Bones, bombs, and break points: The geography of economic activity. *American Economic Review*, 92(5):1269–1289.

Donaldson, D. (2015). The gains from market integration. *Annual Review of Economics*, 7(1):619–647.

Donaldson, D. (2018). Railroads of the raj: Estimating the impact of transportation infrastructure. *American Economic Review*.

Emran, M. S. and Hou, Z. (2013). Access to markets and rural poverty: Evidence from household consumption in china. *Review of Economics and Statistics*, 95(2):682–697.

Emran, M. S. and Shilpi, F. (2012). The extent of the market and stages of agricultural specialization. *Canadian Journal of Economics/Revue canadienne déconomique*, 45(3):1125–1153.

Faber, B. (2014). Trade integration, market size, and industrialization: Evidence from chinas national trunk highway system. *The Review of Economic Studies*, 108((4-5)):899–934.

Fafchamps, M. and Shilpi, F. (2005). Cities and specialisation: Evidence from south asia. *The Economic Journal*, 115(503):477–504.

Jedwab, R., Kerby, E., and Moradi, A. (2017). History, path dependence and development: Evidence from colonial railways, settlers and cities in kenya. *The Economic Journal*, 127(603):1467–1494.

Jedwab, R. and Moradi, A. (2016). The permanent effects of transportation revolutions in poor countries: Evidence from africa. *Review of Economics and Statistics*, 98(2):268–284.

Kanbur, R. and Venables, A. J., editors (2005). *Spatial Inequality and Development*. Oxford University Press.

Miguel, E. and Roland, G. (2011). The long-run impact of bombing vietnam. *Journal of Development Economics*, 96(1):1–15.

Milgrom, P. and Roberts, J. (1992). *Economics, Organization, and Management*. Prantice Hall.

Redding, S. and Turner, M. (2015). Transportation costs and the spatial organization of economic activity. pages 1339–1398.

Redding, S. J. and Sturm, D. M. (2008). The costs of remoteness: Evidence from german division and reunification. *American Economic Review*, 98(5):1766–1797.

Storeygard, A. (2016). Farther on down the road: Transport costs, trade and urban growth in sub-saharan africa. *The Review of Economic Studies*, 83(3):1263–1295.

Table 1: Pre-war Characteristics of Communes/Departments:
Abidjan vs. non-Abidjan Routes

	Share of total employment in			Growth of density of		Density of
	Agriculture	Manufacturing	Services	Building	Nightlights	Population
	(1)	(2)	(3)	(4)	(5)	(6)
		Panel A			**Panel B**	
Non-Abidjan dummy (D_{NA})	**0.004**	**0.006**	**-0.010**	**0.004**	**-0.022**	**0.034**
	(0.017)	**(0.003)**	**(0.017)**	**(0.004)**	**(0.041)**	**(0.038)**
Log (distance to nearest route)	0.003	0.005	-0.008	-0.008**	-0.042	-0.131***
	(0.008)	(0.005)	(0.004)	(0.003)	(0.031)	(0.017)
Log (population density in 1975)	-0.027***	0.003	0.024***	0.015**	-0.015	0.675***
	(0.007)	(0.002)	(0.005)	(0.004)	(0.016)	(0.031)
Mali (yes=1)	-0.051	0.017*	0.034	-0.009*	-0.057	0.305***
	(0.026)	(0.008)	(0.019)	(0.004)	(0.045)	(0.071)
Intercept	1.003***	-0.015	0.012	0.006	0.438**	1.407***
	(0.021)	(0.016)	(0.011)	(0.013)	(0.155)	(0.153)
Observations	1,000	1,000	1,000	929	889	1,000

Notes: (1) Table reports coefficients from Difference-in-Difference regressions during the pre-war period. The first row shows the differences between Abidjan and non-Abidjan routes conditional on the controls.
(2) Robust standard errors in parentheses. Standard errors are clustered at route level. *** p<0.01, ** p<0.05, * p<0.1

Table 2: Effects of temporary trade shock (Ivorian war) on structural change in Burkina Faso and Mali

	Change in Share of employment in		
	Agriculture	Manufacturing	Services
	(1)	(2)	(3)
Integrated Areas (Top 4.5 deciles of Market Access)			
Non-Abidjan Dummy (D_{NA})*Integrated Dummy ($D_T^{0.45}$)	**-0.047****	**0.036****	**0.038****
	(0.016)	**(0.011)**	**(0.013)**
Non-Abidjan Dummy (D_{NA})	0.050**	-0.041**	-0.043**
	(0.019)	(0.010)	(0.014)
Integrated Dummy ($D_T^{0.45}$)	0.045***	-0.035***	-0.040***
	(0.004)	(0.006)	(0.006)
Intercept	-0.103***	0.060***	0.097***
	(0.010)	(0.010)	(0.011)
Observations	1,000	1,000	1,000
Integrated Areas with better market access (Top 4 deciles)			
Non-Abidjan Dummy (D_{NA})*Integrated Dummy ($D_T^{0.4}$)	**-0.057****	**0.042****	**0.048****
	(0.016)	**(0.011)**	**(0.012)**
Non-Abidjan Dummy (D_{NA})	0.050**	-0.042***	-0.043**
	(0.018)	(0.010)	(0.014)
Integrated Dummy ($D_T^{0.4}$)	0.055***	-0.042***	-0.049***
	(0.004)	(0.006)	(0.006)
Intercept	-0.108***	0.063***	0.100***
	(0.010)	(0.010)	(0.014)
Observations	950	950	950
Integrated Areas with better market access (Top 3 deciles)			
Non-Abidjan Dummy (D_{NA})*Integrated Dummy ($D_T^{0.3}$)	**-0.063*****	**0.044*****	**0.053*****
	(0.015)	**(0.011)**	**(0.012)**
Non-Abidjan Dummy (D_{NA})	0.050**	-0.042***	-0.042**
	(0.018)	(0.010)	(0.014)
Integrated Dummy ($D_T^{0.3}$)	0.061***	-0.046***	-0.052***
	(0.004)	(0.006)	(0.007)
Intercept	-0.109***	0.066***	0.100***
	(0.010)	(0.011)	(0.015)
Observations	850	850	850

Notes: (1) The dependent variables are change in employment shares between 1996 and 2006 Burkina Faso and 1998 and 2008 for Mali. Integrated areas are those with pre-war market access in top 4.5 deciles. Table reports the coefficients from Difference in Difference regression. Fixed effects are implemented by first differencing to wipe out time invariant characteristics. Regressions control for log(distance to route), log(population density in 1975) and a dummy for communes in Mali.
(2) Robust standard errors in parentheses. Standard errors are clustered at route level. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Effects of Temporary trade shock (Ivorian war) on sunk investment in Burkina Faso and Mali
(Dependent Variable: change in the share of built-up area)

	Integrated Areas	Integrated areas with better market access	
	$D_T^{0.45}$	$D_T^{0.4}$	$D_T^{0.3}$
	(1)	(2)	(3)
Non-Abidjan Dummy (D_{NA})*Integrated Dummy (D_T^{σ})* D_{2014}	**0.026***	**0.028***	**0.029**
	(0.011)	**(0.011)**	**(0.015)**
Non-Abidjan Dummy (D_{NA})* D_{2014}	0.000	0.000	0.000
	(0.002)	(0.002)	(0.002)
Non-Abidjan Dummy (D_{NA})	0.006	0.005	0.005
	(0.011)	(0.011)	(0.010)
Integrated Dummy (D_T^{σ})* D_{2014}	0.016***	0.017***	0.024***
	(0.001)	(0.001)	(0.002)
Y_{2014}	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
Non-Abidjan Dummy (D_{NA})*Integrated Dummy (D_T^{σ})	-0.006	-0.005	-0.004
	(0.012)	(0.012)	(0.013)
Integrated Dummy (D_T^{σ})	-0.001	-0.000	0.004
	(0.008)	(0.008)	(0.008)
Intercept	-0.003	-0.005	-0.005
	(0.021)	(0.022)	(0.024)
Observations	1,858	1,764	1,578

Notes: (1) Y_{2014} is a dummy that takes a value of unity for the change from 2000 to 2014 and zero otherwise. Integrated areas are those with pre-war market access in top 4.5 deciles. Table reports the coefficients from Difference-in-Difference-in-Difference regression. Fixed effects are implemented by first differencing to wipe out time invariant characteristics. Regressions control for log(distance to route), log(population density in 1975) and a dummy for communes in Mali.
(2) Robust standard errors in parentheses. Standard errors are clustered at route level. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Effects of Temporary trader shock (Ivorian war) on sunk investment in Burkina Faso and Mali (Dependent Variable: growth in average nightlight luminosity)

	Integrated Area	Integrated areas with better market access	
	$D_T^{0.45}$	$D_T^{0.4}$	$D_T^{0.3}$
	(1)	(2)	(3)
Non-Abidjan Dummy (D_{NA})*Integrated Dummy (D_T^{σ})* War Dummy	**0.360*** **	**0.288** **	**0.129**
	(0.072)	**(0.075)**	**(0.099)**
Non-Abidjan Dummy (D_{NA})*Integrated Dummy (D_T^{σ})* Post-war Dummy	**0.269***	**0.196**	**0.032**
	(0.105)	**(0.115)**	**(0.129)**
Non-Abidjan Dummy (D_{NA})* War Dummy	-0.147**	-0.147**	-0.148**
	(0.057)	(0.057)	(0.057)
Non-Abidjan Dummy (D_{NA})* Post-War Dummy	-0.176	-0.176	-0.176
	(0.091)	(0.091)	(0.092)
Non-Abidjan Dummy (D_{NA})	0.083	0.084	0.079
	(0.055)	(0.053)	(0.050)
War Dummy* Integrated Dummy (D_T^{σ})	-0.253**	-0.270***	-0.104
	(0.063)	(0.056)	(0.055)
Post-War Dummy* Integrated Dummy (D_T^{σ})	-0.159	-0.188*	-0.064
	(0.084)	(0.076)	(0.073)
Integrated Dummy (D_T^{σ})* Non-Abidjan Dummy (D_{NA})	0.118*	0.118*	0.118*
	(0.054)	(0.054)	(0.054)
Integrated Dummy (D_T^{σ})	0.260**	0.260**	0.260**
	(0.082)	(0.082)	(0.082)
War Dummy	-0.333***	-0.080	0.049
	(0.053)	(0.090)	(0.109)
Post-war Dummy	0.152***	0.088*	-0.014
	(0.033)	(0.040)	(0.033)
Intercept	0.276***	0.283***	0.245***
	(0.036)	(0.042)	(0.053)
Observations	2,991	2,843	2,544

Notes: (1) War is a dummy that takes a value of unity for 2002-2007 (Ivorian war) and zero otherwise. Post-war dummy is equal to one for all years after 2007 and zero otherwise. Integrated areas are those with pre-war market access in top 4.5 deciles. Table reports the coefficients from Difference in Difference in Difference regression. Fixed effects are implemented by first differencing to wipe out time invariant characteristics. Regressions control for log(distance to route), log(population density in 1975) and a dummy for communes in Mali.
(2) Robust standard errors in parentheses. Standard errors are clustered at route level. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Effects of temporary trade shock (Ivorian war) on Skill Agglomeration in Burkina Faso and Mali
(Dependent variables: change in the share of labor force with secondary or more education)

	Integrated Areas	Integrated areas with better market access	
	$D_T^{0.45}$	$D_T^{0.4}$	$D_T^{0.3}$
	(1)	(2)	(3)
Non-Abidjan Dummy (D_{NA})*Integrated Dummy (D_T^{σ})	**0.016****	**0.012***	**0.016****
	(0.006)	**(0.005)**	**(0.006)**
Non-Abidjan Dummy (D_{NA})	-0.014***	-0.014***	-0.014***
	(0.003)	(0.003)	(0.003)
Integrated Dummy (D_T^{σ})	0.001	0.001	0.001
	(0.002)	(0.002)	(0.002)
Intercept	0.028**	0.028**	0.028**
	(0.008)	(0.008)	(0.008)
Observations	1,000	1,000	1,000

Notes: (1) Integrated areas are those with pre-war market access in top 4.5 deciles. Table reports the coefficients from Difference in Difference regression. Fixed effects are implemented by first differencing to wipe out time invariant characteristics. Regressions control for log (distance to route), log (population density in 1975) and a dummy for communes in Mali.
(2) Robust standard errors in parentheses. Standard errors are clustered at route level. *** p<0.01, ** p<0.05, * p<0.1

Table 6: Effects of temporary trade shock (Ivorian war) on population density in Burkina Faso and Mali
(Dependent variables: Change in log (population density))

	Integrated Areas	Integrated areas with better market access	
	$D_T^{0.45}$	$D_T^{0.4}$	$D_T^{0.3}$
	(1)	(2)	(3)
Non-Abidjan Dummy (D_{NA})*Integrated Dummy (D_T^{σ})	**0.037**	**0.040**	**0.057***
	(0.025)	**(0.026)**	**(0.026)**
Non-Abidjan Dummy (D_{NA})	-0.032	-0.034	-0.036
	(0.029)	(0.030)	(0.031)
Integrated Dummy (D_T^{σ})	0.018	0.015	0.006
	(0.021)	(0.021)	(0.020)
Intercept	0.458***	0.459***	0.442***
	(0.017)	(0.020)	(0.025)
Observations	1,000	950	850

Notes: (1) Integrated areas are those with pre-war market access in top 4.5 deciles. Table reports the coefficients from Difference in Difference regression. Fixed effects are implemented by first differencing to wipe out time invariant characteristics. Regressions control for log(distance to route), log(population density in 1975) and a dummy for communes in Mali.
(2) Robust standard errors in parentheses. Standard errors are clustered at route level. *** p<0.01, ** p<0.05, * p<0.1

Figure 1: West Africa Main ports and transport routes

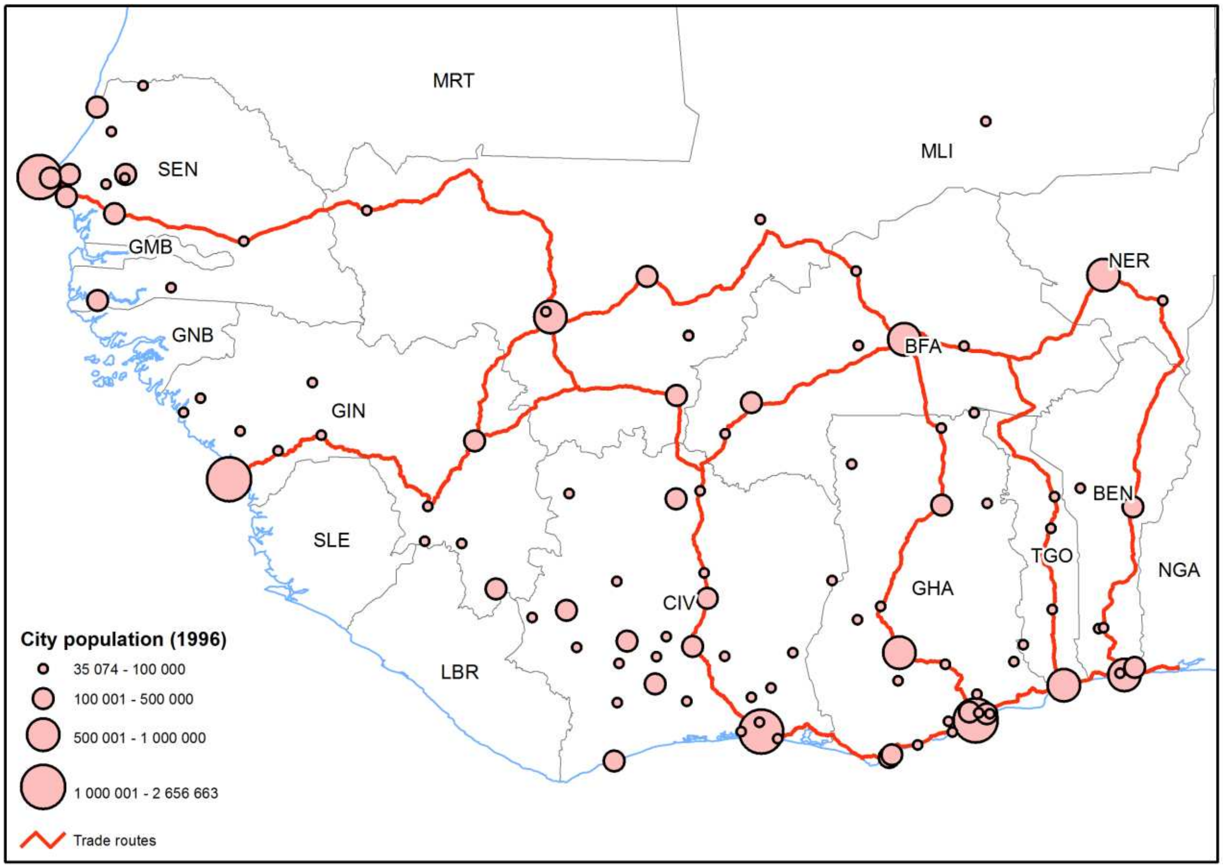
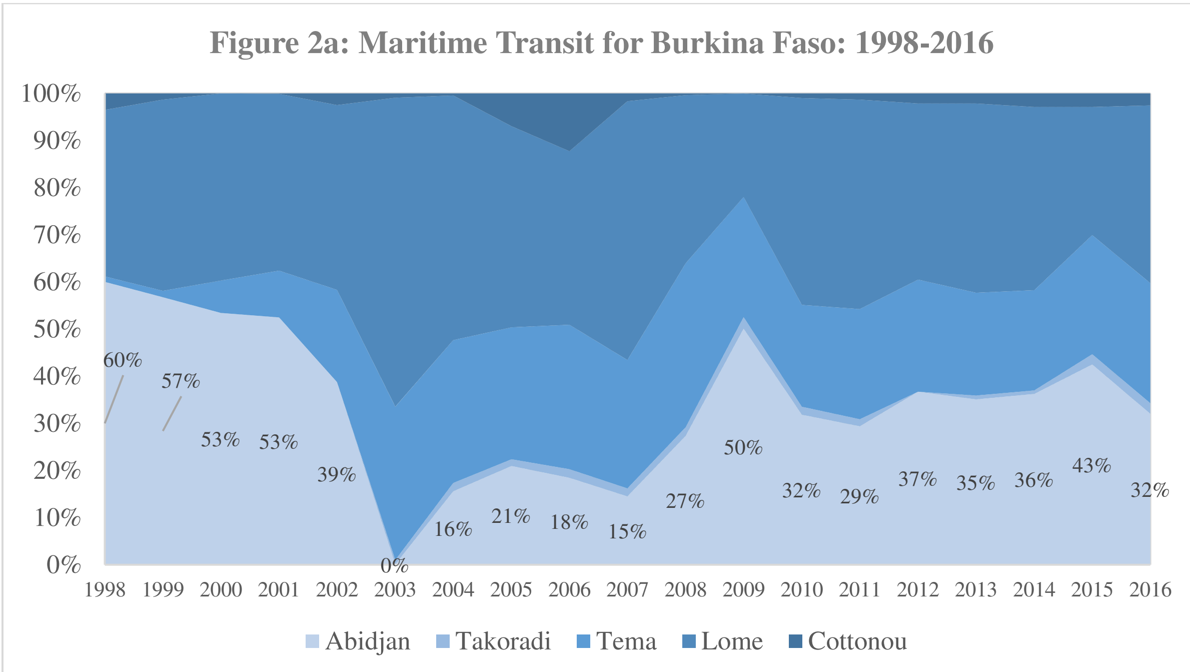
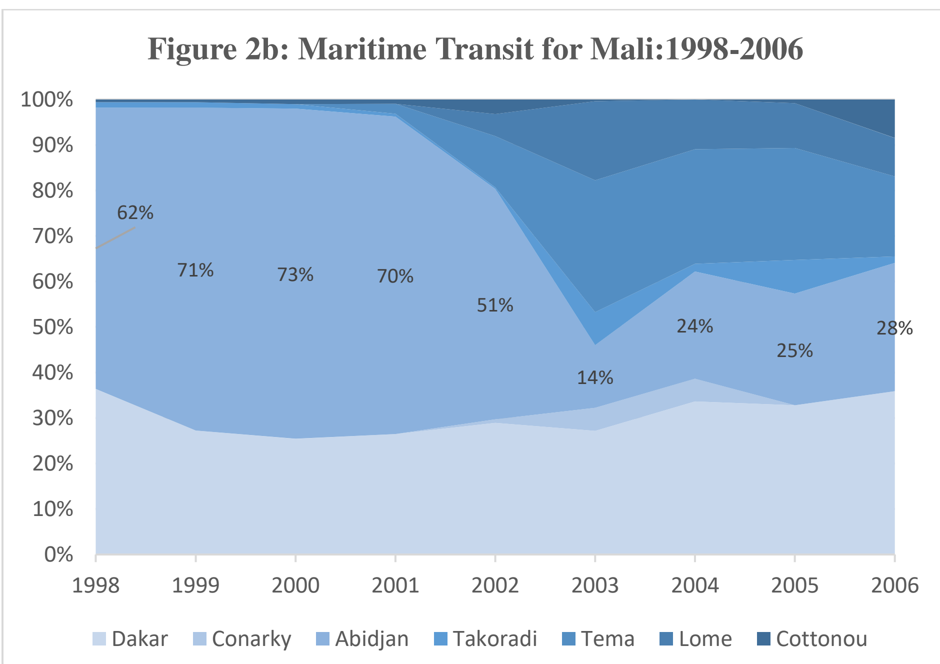


Figure 2: Maritime Transit through West African ports for Burkina Faso and Mali





Source:

Figure 3: Pre-Crisis Equilibrium Pattern of population and built-up densities and employment pattern

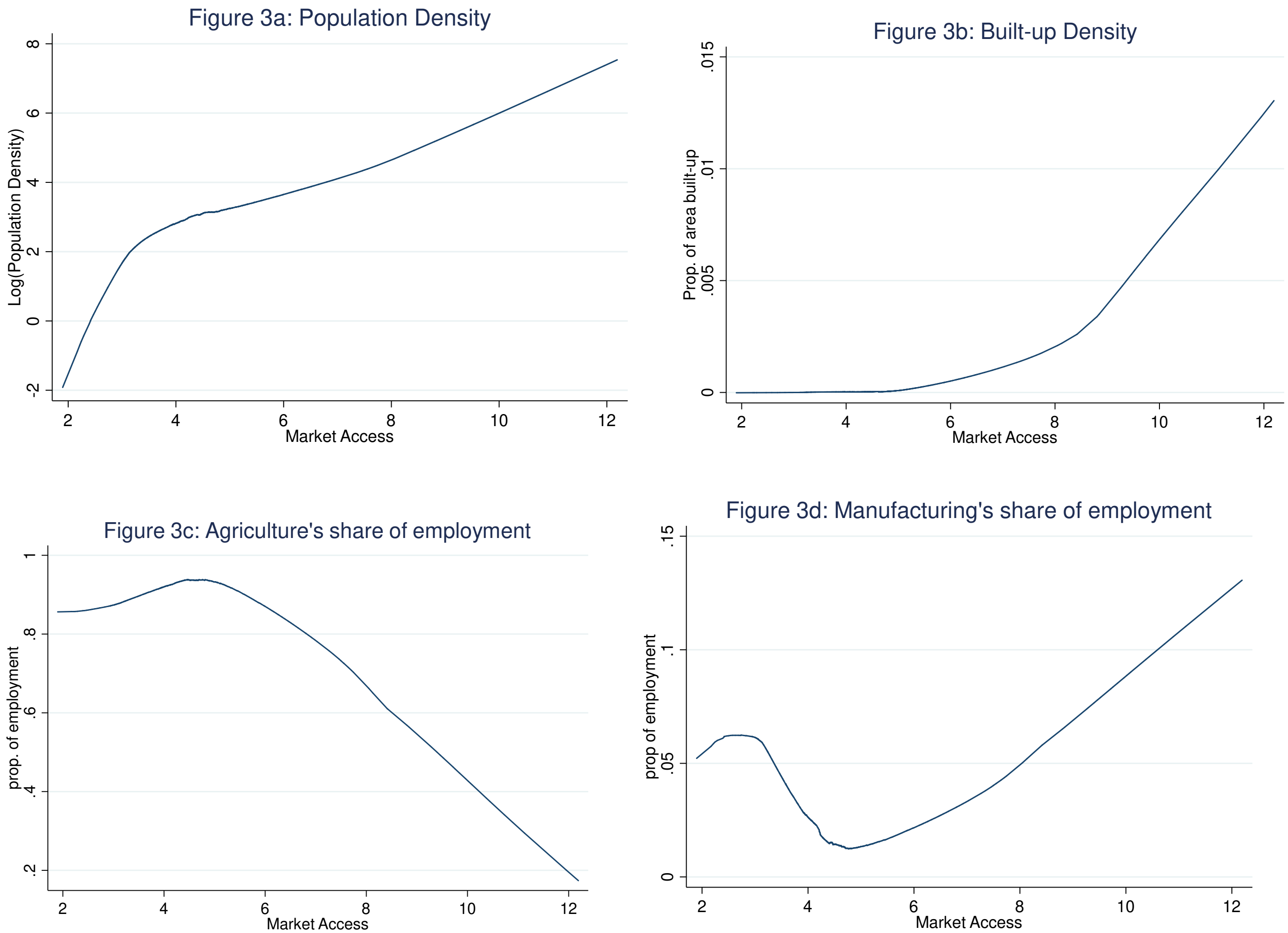


Figure 4: Distribution of Market Access

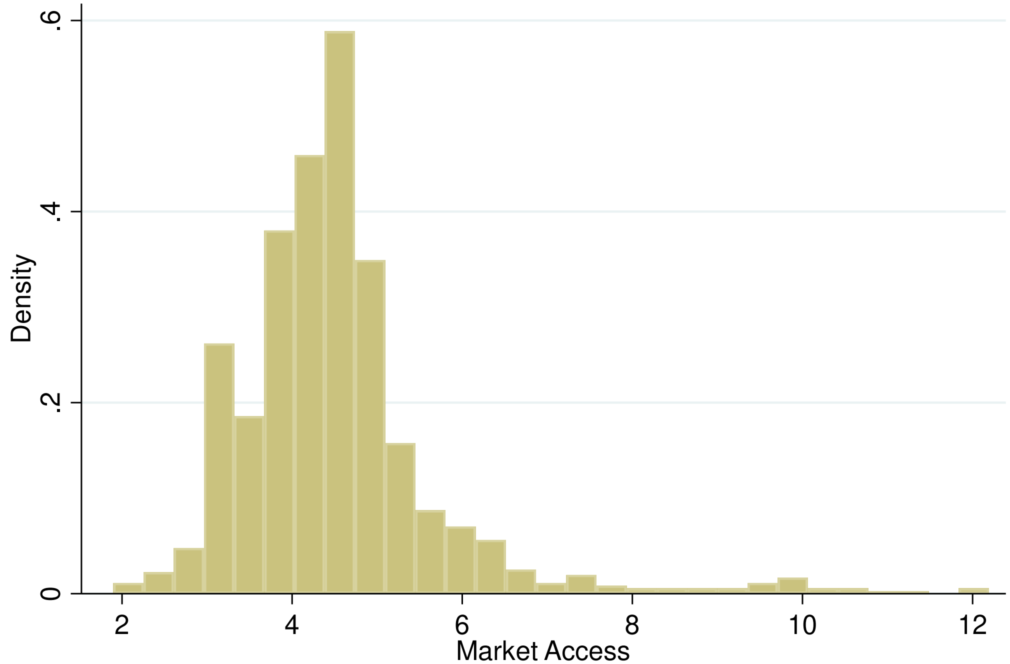
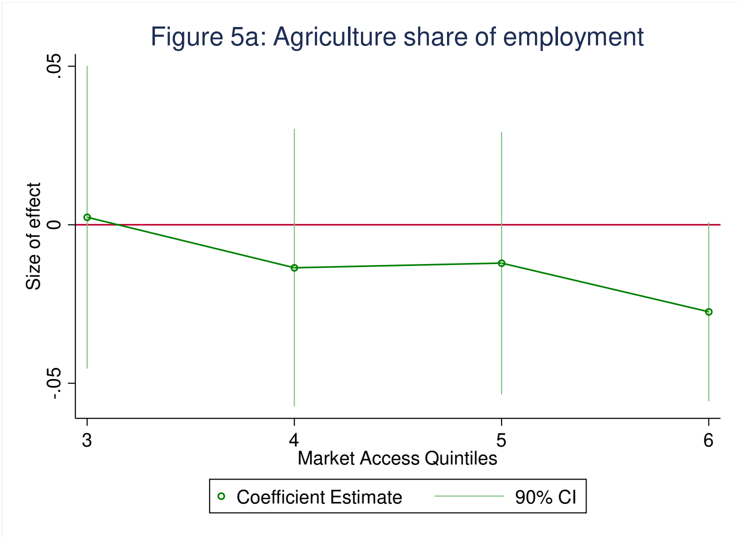
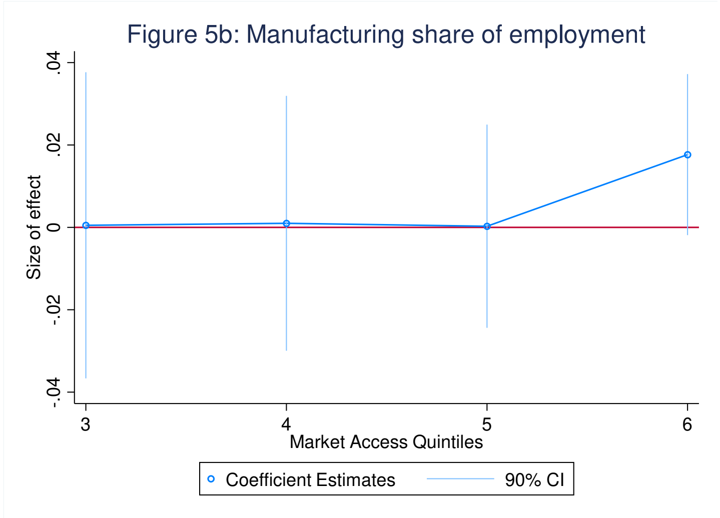
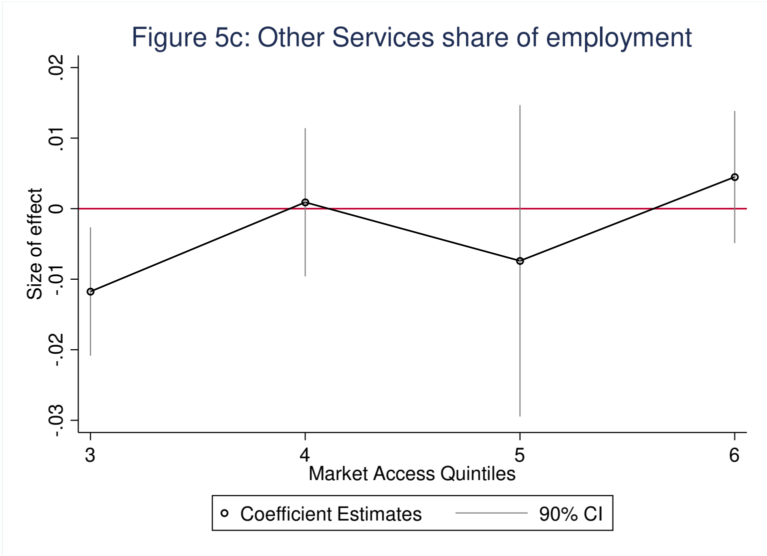


Figure 5: Effects of CIV crisis on employment shares by market access quintiles







Online Appendix to the Conceptual Framework: Not for Publication

Equilibrium in the Isolated Sub-region

Assuming that land rental is shared equally by all workers in a location i, and using the first order conditions along with equilibrium conditions for goods and services, allocation of land across activities can be derived as

$$\begin{aligned} T_{xi} &= \frac{\beta\delta T}{1-(\gamma+\delta+\eta)(1-\beta)}; T_{mi} = \frac{\beta\gamma T}{1-(\gamma+\delta+\eta)(1-\beta)} \\ T_{zi} &= \frac{\beta\eta T}{1-(\gamma+\delta+\eta)(1-\beta)}; T_{hi} = \frac{(1-\gamma-\delta)T}{1-(\gamma+\delta+\eta)(1-\beta)} \end{aligned}$$

and allocation of labor as

$$L_{xi} = \frac{\delta N_i}{(\gamma+\delta+\eta)}, L_{mi} = \frac{\gamma N_i}{(\gamma+\delta+\eta)}, L_{zi} = \frac{\eta N_i}{(\gamma+\delta+\eta)}$$

where N_i is the total number of workers living and working in location i. The relative price of manufacturing and agriculture can be expressed as

$$\frac{P_{mi}}{P_{qi}} = \frac{A_{qi} L_{qi}^{-\beta} T_{qi}^{\beta}}{A_{mi} T_{mi}^{\beta} L_{mi}^{-\beta}} = \frac{A_{qi}}{A_{mi}}, q \in \{x, z\}$$

Noting that $\frac{T_{xi}}{L_{xi}} = \frac{\beta(\gamma+\delta)T}{[1-(\gamma+\delta)(1-\beta)]N_i} = \beta\mu\frac{T}{N_i} = \beta\mu/n_i$, relative price of housing can be derived as

$$\frac{P_{hi}}{P_{xi}} = \frac{\beta^{\beta} A_{xi} n_i{}^{(1-\beta)}}{A_h \mu^{(1-\beta)}}$$

The labor mobility condition implies that

$$W_i = \frac{\nu(1-\beta) P_{mi}^{\gamma} P_{xi}^{\delta} P_{zi}^{\eta} P_{si}^{1-\gamma-\delta-\eta}}{z_1} = \overline{v} P_{mi}^{\gamma} P_{xi}^{\delta} P_{zi}^{\eta} P_{si}^{1-\gamma-\delta-\eta}$$

where $\overline{v} = \frac{\nu(1-\beta)}{z_1}. z_1 = \gamma^{\gamma}\delta^{\delta}\eta^{\eta}(1-\gamma-\delta-\eta)^{1-\gamma-\delta-\eta}$ and ν is the equalized indirect utility. We solve for n_i using marginal condition for labor use as

$$n_i = [\frac{z_2 \bar{A}_x^{\delta} \bar{A}_m^{\gamma} \bar{A}_z^{\eta}}{\overline{v}}]^{\frac{1}{\beta^* - \alpha_1}}$$

where $z_2 = (1-\beta)\beta^{\beta(\gamma+\delta)}\mu^{1-(1-\beta)(\gamma+\delta+\eta)} A_h^{1-\gamma-\delta-\eta}, \beta^* = 1-(1-\beta)(\gamma+\delta+\eta)$ and $\alpha_1 = \alpha_x\delta+\alpha_m\gamma+\alpha_z\eta$. Population density within isolated subregion is function of productivity and preference parameters which do not change across areas. Thus population density is constant across areas within isolated subregion.Since same fraction of land is used for housing, and population density is constant, it follows that housing density does not vary across areas as well.

Equilibrium in Integrated Sub-region

Land and Labor allocation:

Since housing is non-traded, its land share does not vary across areas and is equal to $T_{hi} = \frac{(1-\gamma-\delta)T}{1-(\gamma+\delta+\eta)(1-\beta)} \forall i$.Using first order conditions, land allocation among traded goods in different specialization zones can be determined as

$$\begin{aligned} T_{zi} &= \frac{\beta(\gamma+\delta+\eta)T_i}{1-(\gamma+\delta+\eta)(1-\beta)}, \forall i \in [K^0, K^Z] \\ T_{xi} &= \frac{\beta(\gamma+\delta+\eta)T_i}{1-(\gamma+\delta+\eta)(1-\beta)}, \forall i \in [K^Z, K^S] \\ T_{xi} &= \frac{\beta(\gamma+\delta)T_i}{1-(\gamma+\delta+\eta)(1-\beta)}; T_{zi} = \frac{\beta\eta T_i}{1-(\gamma+\delta+\eta)(1-\beta)}, \forall i \in [K^S, K^A] \end{aligned}$$

Similarly, labor allocation among different goods can be defined as

$$\begin{aligned} L_{zi} &= N_i, \forall i \in [K^0, K^Z] \\ L_{xi} &= N_i, \forall i \in [K^Z, K^S] \\ L_{xi} &= \frac{(\gamma+\delta)N_i}{(\gamma+\delta+\eta)}; L_{zi} = \frac{\eta N_i}{(\gamma+\delta+\eta)}, \forall i \in [K^S, K^A] \end{aligned}$$

Population density

Consider a location $i \in [K^0, K^Z]$. The labor mobility condition implies that

$$\overline{v} = \frac{W_i}{P_{mi}^{\gamma} P_{xi}^{\delta} P_{zi}^{\eta} P_{si}^{1-\gamma-\delta-\eta}}$$

From the first order conditions for labor and land, we have

$$\frac{P_{hi}}{P_{zi}} = \frac{\beta A_{zi} T_{zi}^{\beta-1} L_{zi}^{(1-\beta)}}{A_h} = \frac{\beta^{\beta} \mu^{\beta-1} n_i^{1-\beta} A_{zi}}{A_h}$$

where $\mu = \frac{(\gamma+\delta+\eta)}{1-(\gamma+\delta+\eta)(1-\beta)}$.Using first order condition, we have

$$
\begin{aligned}
(1-\beta)A_{zi}T_z^{\beta}L_{zi}^{-\beta} &= \frac{W_i}{P_{zi}} \\
(1-\beta)A_{zi}[\frac{\beta\mu T}{N_i}]^{\beta} &= \frac{\overline{v}P_{mi}^{\gamma}P_{xi}^{\delta}P_{zi}^{\eta}P_{hi}^{1-\gamma-\delta-\eta}}{P_{zi}} = \overline{v}\frac{P_{zi}^{\gamma}}{P_{mi}^{\gamma}}\frac{P_{zi}^{\delta}}{P_{xi}^{\delta}}\frac{P_{zi}^{1-\gamma-\delta-\eta}}{P_{hi}^{1-\gamma-\delta-\eta}} \\
\overline{v}n_i^{\beta} &= (1-\beta)(\beta\mu)^{\beta}A_{zi}\frac{P_{zi}^{\gamma}}{P_{mi}^{\gamma}}\frac{P_{zi}^{\delta}}{P_{xi}^{\delta}}[\frac{A_h}{(\beta^{\beta}\mu^{\beta-1}n_i^{1-\beta}A_{zi}}]^{1-\gamma-\delta-\eta} \\
\overline{v}n_i^{\beta+(1-\beta)(1-\gamma-\delta-\eta)} &= z_2A_{zi}^{\gamma+\delta+\eta}\frac{P_{zi}^{\gamma}}{P_{mi}^{\gamma}}\frac{P_{zi}^{\delta}}{P_{xi}^{\delta}}
\end{aligned}
$$

where $z_2 = (1-\beta)\beta^{\beta(\gamma+\delta)}\mu^{1-(1-\beta)(\gamma+\delta)}A_h^{1-\gamma-\delta-\eta}$.Noting that relative prices are $\frac{P_{zi}}{P_{mi}} = \frac{P_{zK^0}}{P_{mK^0}}e^{-(\tau_m+\tau_x)d_i}$, $\frac{P_{zi}}{P_{xi}} = \frac{P_{zK^0}}{P_{mK^0}}e^{-(\tau_z+\tau_x)d_i}$ and substituting for $A_{mi} = \bar{A}_{mi}n_i^{\alpha_m}; \quad A_{zi} = \bar{A}_{zi}n_i^{\alpha_z}$

substituting for $A_{xi} = \bar{A}_x n_i^{\alpha_x};\ A_{mi} = \bar{A}_{mi}n_i^{\alpha_m}; \quad A_{zi} = \bar{A}_{zi}n_i^{\alpha_z}$

$$
n_i = [\frac{z_2\bar{A}_z^{\gamma+\delta+\eta}}{\overline{v}}\frac{P_{zK^0}^{\gamma}}{P_{mK^0}^{\gamma}}\frac{P_{zK^0}^{\delta}}{P_{xK^0}^{\delta}}]^{\frac{1}{\beta^*-\alpha_4}}e^{-\frac{\tau_4}{\beta^*-\alpha_4}d_i}
$$

where $\alpha_4 = \alpha_z(\delta+\gamma+\eta), \tau_4 = (\tau_m+\tau_z)\gamma+\delta(\tau_z-\tau_x)$.

Using the same steps, we can derive population density in other specialization zones as:

$$
\begin{aligned}
n_i &= [\frac{z_2\bar{A}_x^{\gamma+\delta+\eta}}{\overline{v}}\frac{P_{xK^0}^{\gamma}}{P_{mK^0}^{\gamma}}\frac{P_{xK^0}^{\eta}}{P_{zK^0}^{\eta}}]^{\frac{1}{\beta^*-\alpha_4}}e^{-\frac{\tau_3}{\beta^*-\alpha_3}d_i}, \forall i \in [K^Z, K^S] \\
&= [\frac{z_2\bar{A}_x^{\gamma+\delta}\bar{A}_z^{\eta}}{\overline{v}}\frac{P_{xK^0}^{\gamma}}{P_{mK^0}^{\gamma}}]^{\frac{1}{\beta^*-\alpha_2}}e^{-\frac{\tau_2}{\beta^*-\alpha_2}d_i}, \forall i \in [K^S, K^*]
\end{aligned}
$$

where $\alpha_2 = \alpha_x(\delta+\gamma)+\alpha_z\eta; \tau_2 = (\tau_m+\tau_x)\gamma; \alpha_3 = \alpha_x(\delta+\gamma+\eta), \tau_3 = (\tau_m+\tau_z)\gamma+\eta(\tau_x-\tau_z)$.It is clear from above equations that population density (n_i) decreases with an increase in i which measures the distance from K^0 within the integrated subregion.

Effect of transport costs shock on spatial margins for trade (SMI) and specialization (SMS)

The immediate effect of transport shock is to change the relative price of importable. Consider city center K^0. The immediate impact of transport shock on indirect utility due to changes in relative prices (but no labor movement) can be deduced from the following equation :

$$
\begin{aligned}
\ln(\overline{v}) &= \ln(z_2) + (\gamma+\delta+\eta)\bar{a}_z - (\beta^*-\alpha_4)\ln(n_{k^0}) + (\gamma+\delta)p_{zK^0} - \gamma p_{mK^0} - \delta p_{xK^0} \\
\frac{\partial\overline{v}}{\partial\theta_K} &= (\gamma+\delta)\frac{\partial p_{zK^0}}{\partial\theta_K} - \gamma\frac{\partial p_{mK^0}}{\partial\theta_K} - \delta\frac{\partial p_{xK^0}}{\partial\theta_K} < 0
\end{aligned}
$$

Recall that

$$P_{qk^0} = \tilde{P}_q(1-\theta_k), q \in x, z$$
$$P_{mk^0} = \tilde{P}_m(1+\theta_k)$$

Taking logarithm and differentiating with respect to θ_k, we have

$$\begin{aligned}
p_{qk^0} &= \tilde{p}_q + \ln(1-\theta_k), q \in x, z \\
\frac{\partial p_{qk^0}}{\partial \theta_k} &= -\frac{1}{1-\theta_k} < 0; \frac{\partial p_{mk^0}}{\partial \theta_k} = \frac{1}{1+\theta_k} > 0 \\
\frac{\partial \overline{v}}{\partial \theta_k} &= -\frac{\gamma+\delta}{1-\theta_k} - \frac{\gamma}{1+\theta_k} + \frac{\delta}{1-\theta_k} = -\frac{2\gamma}{1-\theta_k^2} < 0
\end{aligned}$$

This induces population movement out of K and into J. In other words, $\frac{\partial n_{K^0}}{\partial \theta_k} < 0$.

Impacts on SMI and SMS in areas around K: Recall that $SMI = max\{K^S, K^*\}$ and $SMS = K^Z$ and $\frac{\partial n_i}{\partial \theta_k} < 0$ for $\forall i \in [K^0, K^1]$

$$\begin{aligned}
\text{SMS:} \quad & \frac{\partial K^Z}{\partial \theta_k} = \frac{1}{\tau_z - \tau_x}[\frac{1}{n_{K^Z}} \frac{\partial n_{K^Z}}{\partial \theta_k}] < 0; \\
\text{SMI:} \quad & \frac{\partial K^*}{\partial \theta_k} = \frac{1}{(\tau_m + \tau_x)}[-\frac{2}{1-\theta_k^2} + \frac{(\alpha_x - \alpha_m)}{n_{K^A}} \frac{\partial n_{K^*}}{\partial \theta_k}] < 0 \\
\text{SMI:} \quad & \frac{\partial K^S}{\partial \theta_k} = \frac{1}{(\tau_m + \tau_z)}[-\frac{2}{1-\theta_k^2} + \frac{(\alpha_z - \alpha_m)}{n_{K^S}} \frac{\partial n_{K^S}}{\partial \theta_k}] < 0
\end{aligned}$$

Impacts on SMI and SMS in areas around J: For J price ratios are not affected, so main channel for impact is through population movement. Because of an increase in population density ($\frac{\partial n_J}{\partial \theta_k} > 0, \forall j \in [J^0, J^1]$) the following holds.

$$\begin{aligned}
\text{SMS:} \quad & \frac{\partial J^Z}{\partial \theta_k} = \frac{1}{\tau_z - \tau_x}[\frac{1}{n_{J^Z}} \frac{\partial n_{J^Z}}{\partial \theta_k}] > 0 \\
\text{SMI:} \quad & \frac{\partial J^*}{\partial \theta_k} = \frac{1}{(\tau_m + \tau_x)}[\frac{(\alpha_x - \alpha_m)}{n_{J^A}} \frac{\partial n_{J^*}}{\partial \theta_k}] > 0 \\
\text{SMI:} \quad & \frac{\partial J^s}{\partial \theta_k} = \frac{1}{(\tau_m + \tau_z)}[\frac{(\alpha_z - \alpha_m)}{n_{J^S}} \frac{\partial n_{J^S}}{\partial \theta_k}] > 0
\end{aligned}$$

Impact on building density follows from impact on population density and manufacturing employment share.